CHAPTER 3

DESCRIPTION OF THE AFFECTED ENVIRONMENT

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3.1. PHYSICAL ENVIRONMENT

3.1.1. Air Quality

The Clean Air Act established the National Ambient Air Quality Standards (NAAQS); the primary standards are to protect public health and the secondary standards are to protect public welfare. New NAAQS for ozone and particulate matter took effect on September 16, 1997. The current NAAQS (40 CFR 50.12 and 62 FR 138, July 18, 1997) are shown in Table 3-1. The Clean Air Act Amendments of 1990 established classification designations based on regional monitored levels of ambient air quality. These designations impose mandated timetables and other requirements necessary for attaining and maintaining healthful air quality in the U.S. based on the seriousness of the regional air quality problem.

When measured concentrations of regulated pollutants exceed standards established by the NAAQS, an area may be designated as a nonattainment area for a regulated pollutant. The number of exceedances and the concentrations determine the nonattainment classification of an area. There are five classifications of nonattainment status: marginal, moderate, serious, severe, and extreme (Clean Air Act Amendments, 1990).

The Federal OCS waters attainment status is unclassified. The OCS areas are not classified because there is no provision for any classification in the Clean Air Act for waters outside of the boundaries of State waters. Only areas within State boundaries are to be classified either attainment, nonattainment, or unclassifiable. Operations west of 87.5^{o} W. longitude fall under MMS jurisdiction for enforcement of the Clean Air Act. The OCS waters east of 87.5^{o} W. longitude are under the jurisdiction of USEPA. Figure 3-1 presents the air quality status in the Gulf Coast as of August 2001. All air-quality nonattainment areas reported in Figure 3-1 are for ozone nonattainment. No graphics depicting the boundaries (projected from historical data) of ozone areas of influence, areas at risk, or areas of violation along the U.S. Gulf of Mexico coast were available at the time of publishing this EIS. It is expected that the number of areas of violation will increase under the new 8-hr ozone NAAQS as compared to the number of areas under the old 1-hr standard. As of August 2001, the new 8-hr ozone standard had not yet been fully implemented because of pending court action.

Pollutant levels in coastal areas of Texas reported in the *Air Monitoring Report, 1991* (Texas Air Control Board, 1994) were nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), particulate matter (PM_{10}), and ozone (O_3). The State of Texas is considered to be in attainment for the pollutants SO_2 and NO_2. Exceedances of the national standards for CO and PM_{10} have only been measured in the interior of the state. Thus, there have been no exceedances of the NAAQS for SO_2, NO_2, CO, and PM_{10} in Texas coastal areas (also see USEPA, 2001). The following Texas coastal counties are classified as nonattainment for ozone: Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Jefferson, Hardin, and Orange (USEPA, 2001).

Measurements of pollutant concentrations in Louisiana are presented in the *Air Quality Data Annual Report, 1996* (Louisiana Dept. of Environmental Quality, 1996). Louisiana is considered to be in attainment of the NAAQS for CO, SO_2, NO_2, and PM_{10} (also see USEPA, 2001). As of August 2001, six Louisiana coastal zone parishes have been tentatively designated nonattainment for ozone: Iberville, Ascension, Lafourche, East Baton Rouge, West Baton Rouge, and Livingston (USEPA, 2001). Ozone measurements (Louisiana Dept. of Environmental Quality, written communication, 1997) between 1989 and 1997 show that the number of days exceeding the national standards are declining.

Air quality data for 1993 were obtained from the Alabama Department of Environmental Management for PM_{10}, NO_2, and O_3. The data shows that Mobile County is in attainment of the NAAQS for all criteria pollutants. There have been no exceedances of the NAAQS for SO_2, NO_x, CO, and PM_{10} in the State of Alabama (USEPA, 2001).

The State of Florida has no nonattainment areas in its coastal counties (USEPA, 2001). Relative to onshore air quality in Escambia County, USEPA's Aerometric Information Retrieval System was accessed for ambient air monitoring data of SO_2, O_3, and PM_{10} for the years 1995 through 1997. During this period, the following exceedances of applicable standards were recorded: no measurements of SO_2; three measurements of O_3 (one in 1995 and two in 1996); and no measurements of PM_{10}. If the proposed, new, 8-hr ozone standard is imposed using the 1996-1998 data, Escambia County would be in violation. Indeed, during the 1998 summer season, there were a number of ozone alerts.

Prevention of Significant Deterioration (PSD) Class I air quality areas, designated under the Clean Air Act, are afforded the greatest degree of air quality protection and are protected by stringent air quality standards that allow for very little deterioration of their air quality. The PSD maximum allowable pollutant increase for Class I areas are as follows: 2.5 $\mu g/m^3$ annual increment for NO_2; 25 $\mu g/m^3$ 3-hr increment, 5 $\mu g/m^3$ 24-hr increment, and 2 $\mu g/m^3$ annual increment for SO_2; and 8 $\mu g/m^3$ 24-hr increment and 5 $\mu g/m^3$ annual increment for PM_{10}. The CPA includes the Breton National Wildlife Refuge and National Wilderness Area south of Mississippi, which is designated as a PSD Class I area. The U.S. Fish and Wildlife Service (FWS) has responsibility for protecting wildlife, vegetation, visibility, and other sensitive resources called air-quality-related values in this area. The FWS has expressed concern that the NO_2 and SO_2 increments for the Breton National Wilderness Area have been consumed. There is no PSD Class I air quality area in the WPA.

Ambient air quality is a function of the size, distribution, and activities directly related with population in association with the resulting economic development, transportation, and energy policies of the region. Meteorological conditions and topography may confine, disperse, or distribute air pollutants. Assessments of air quality depend on multiple variables such as the quantity of emissions, dispersion rates, distances from receptors, and local meteorology. Due to the variable nature of these independent factors, ambient air quality is an ever-changing dynamic process.

3.1.2. Water Quality

For the purposes of this EIS, water quality is the ability of a waterbody to maintain the ecosystems it supports or influences. In the case of coastal and marine environments, the quality of the water is influenced by the rivers that drain into the area, the quantity and composition of wet and dry atmospheric deposition, and the influx of constituents from sediments. Besides the natural inputs, human activity can contribute to water quality through discharges, run-off, burning, dumping, air emissions, and spills. Also, mixing or circulation of the water can either improve the water through flushing or be the source of factors contributing to the decline of water quality.

Evaluation of water quality is done by direct measurement of factors that are considered important to the health of an ecosystem. The primary factors influencing coastal and marine environments are temperature, salinity, oxygen, nutrients, pH, pathogens, and turbidity or suspended load. Trace constituents such as metals and organic compounds can affect water quality. Altering the ecosystem through changes in any of these parameters can result in the destruction of specific species, support of undesirable or exotic species, and possibly mass mortality. The effects can either be localized or widespread.

The region under consideration is divided into coastal and marine waters for the following discussion. Coastal waters, as defined by MMS, include all the bays and estuaries from the Rio Grande River to the Florida Bay (Figure 3-2). Marine water as defined in this document includes both State offshore water and Federal OCS waters, which includes everything outside any barrier islands to the Exclusive Economic Zone. The inland extent is defined by the Coastal Zone Management Act.

3.1.2.1. Coastal Waters

Along the U.S. Gulf Coast lies one of the most extensive estuary systems in the world, which extends from the Rio Grande River to Florida Bay (Figure 3-2). Estuaries represent a transition zone between the freshwater of rivers and the higher salinity waters offshore. These bodies of water are influenced by freshwater and sediment influx from rivers and the tidal actions of the oceans. The primary variables that influence coastal water quality are water temperature, total dissolved solids (salinity), suspended solids (turbidity), and nutrients. An estuary's salinity and temperature structure is determined by hydrodynamic mechanisms governed by the interaction of marine and terrestrial influences, including tides, nearshore circulation, freshwater discharges from rivers, and local precipitation. Gulf Coast estuaries exhibit a general east to west trend in selected attributes of water quality associated with changes in regional geology, sediment loading, and freshwater inflow.

Estuaries provide habitat for plants, animals, and humans. Marshes, mangroves, and seagrasses surround the Gulf Coast estuaries, providing food and shelter for shorebirds, migratory waterfowl, fish, invertebrates (e.g., shrimp, crabs, and oysters), reptiles, and mammals. Estuarine-dependent species constitute more than 95 percent of the commercial fishery harvests from the Gulf of Mexico. Several major cities are located along the coast, including Houston, New Orleans, Mobile, and Tampa. Tourism supplies an estimated $20 billion to the economy each year (USEPA, 1999). Shipping and marine transport is an important industry, with 7 of the top 10 busiest ports in the U.S., in terms of total tonnage, located in Gulf estuaries.

Estuarine ecosystems are impacted by humans, primarily via upstream withdrawals of water for agricultural, industrial, and domestic purposes; contamination by industrial and sewage discharges and agricultural runoff carrying pesticides and herbicides; and habitat alterations (e.g., construction and dredge and fill operations). Drainage from more than 55 percent of the conterminous U.S. enters the Gulf of Mexico, primarily from the Mississippi River. Texas, Louisiana, and Alabama ranked first, second, and fourth in the nation in 1995 in terms of discharging the greatest amount of toxic chemicals (USEPA, 1999). The Gulf of Mexico region ranks highest of all coastal regions in the U.S. in the number of wastewater treatment plants (1,300), number of industrial point sources (2,000), percent of land use devoted to agriculture (31%), and application of fertilizer to agricultural lands (62,000 tons of phosphorus and 758,000 tons of nitrogen) (USDOC, NOAA, 1990).

A recent assessment of the ecological condition of Gulf of Mexico estuaries was published by the USEPA (1999). The assessment describes the general ecology and summarizes the "health" of all the Gulf estuarine systems. Sources of the data include the USEPA's Environmental Monitoring and Assessment Program for Estuaries (EMAP-E), the NOAA Estuarine Eutrophication Survey (USDOC, NOAA, 1997a), and 305(b) reports from each state. A classification scheme based on designated beneficial uses was developed. Estuaries are classified primarily by aquatic life support, fish consumption, or recreation and whether they are fully, partially, or not supporting of these uses. From 1996 305(b) data, 78 percent of Gulf estuaries were surveyed with 35 percent of the surveyed estuaries designated as impaired. Factors resulting in impairment were pathogen indicators (e.g., fecal coliform) and eutrophication indicators (e.g., nutrients, organic enrichment, and low dissolved oxygen).

3.1.2.2. Marine Waters

The marine water, within the area of interest, can be divided into three regions: the continental shelf west of the Mississippi River, the continental shelf east of the Mississippi River, and deepwater (> 400 m). For this discussion, the continental shelf includes the upper slope to a water depth of 400 m. While the various parameters measured to evaluate water quality do vary in marine waters, one parameter, pH, does not. The buffering capacity of the marine system is controlled by carbonate and bicarbonate, which maintains the pH at 8.2.

Continental Shelf West of the Mississippi River

The Mississippi and Atchafalaya Rivers are the primary sources of freshwater, sediment, and pollutants to the continental shelf west of the Mississippi (Murray, 1997). The drainage basin that feeds the rivers covers 55 percent of the contiguous United States. While the average river discharge from the Mississippi River exceeds the input of all other rivers along the Texas-Louisiana coast by a factor of 10, during low-flow periods, the Mississippi River can have a flow less than all the other rivers combined (Nowlin et al., 1998). A turbid surface layer of suspended particles is associated with the freshwater plume. A nepheloid layer composed of suspended clay material from the underlying sediment is always present on the shelf. The river system supplies nitrate, phosphate, and silicate to the shelf. During summer months, the low-salinity water from the Mississippi River spreads out over the shelf, resulting in a stratified water column. While surface oxygen concentrations are at or near saturation, hypoxia, defined as oxygen concentrations less than 2 milligrams per liter (mg/l) O_2, is observed in bottom waters during the summer months.

The zone of hypoxia on the Louisiana-Texas shelf is one of the largest areas of low oxygen in the world's coastal waters (Murray, 1997). The oxygen-depleted bottom waters occur seasonally and are affected by the timing of the Mississippi and Atchafalaya River discharges carrying nutrients to the surface waters. This, in turn, increases the carbon flux to the bottom, which, under stratified conditions, results in oxygen depletion to the point of hypoxia (<2 mg/l O_2). The hypoxic conditions last until local wind-driven circulation mixes the water again. The area of hypoxia stretches over 17,000 km^2 at its peak and was observed as far away as Freeport, Texas. Increased nutrient loading since the turn of the 19th century correlates with the increased extent of hypoxic events (Eadie et al., 1992), supporting the theory that hypoxia is related to the nutrient input from the Mississippi and Atchafalaya River systems.

Shelf waters off the coast of Louisiana are contaminated with trace organic pollutants including polynuclear aromatic hydrocarbons (PAH), herbicides, chlorinated pesticides, and polychlorinated biphenyls (PCB's), and trace inorganic (metals) pollutants. Of particular note is the pervasive distribution of the herbicide Atrazine (Murray, 1997). The source of these contaminants is the river water that feeds into the area.

Continental Shelf East of the Mississippi River

Water quality on the continental shelf from the Mississippi River Delta to Tampa Bay is influenced by river discharge, run-off from the coast, and eddies from the Loop Current. The Mississippi River accounts for 72 percent of the total discharge onto the shelf (SUSIO, 1975). The outflow of the Mississippi River generally extends only 75 km (45 mi) to the east of the river mouth (Vittor and Associates, Inc., 1985) except under extreme flow conditions. The Loop current intrudes in irregular intervals onto the shelf, and the water column can change from well mixed to highly stratified very rapidly. Discharges from the Mississippi River can be easily entrained in the Loop Current. The flood of 1993 influenced the entire northeastern Gulf shelf with some Mississippi River water transported to the Atlantic Ocean through the Florida Straits (Dowgiallo, 1994). Hypoxia is rarely observed on the Mississippi-Alabama shelf, although low dissolved oxygen values of 2.93-2.99 mg/l were observed during the MAMES cruises (Brooks, 1991).

The Mississippi-Alabama shelf sediments are strongly influenced by fine sediments discharged from the Mississippi River. The shelf area is characterized by a bottom nepheloid layer and surface lenses of suspended particulates that originate from river outflow. The West Florida Shelf has very little sediment input with primarily high-carbonate sands offshore and quartz sands nearshore. The water clarity is higher towards Florida, where the influence of the Mississippi River outflow is rarely observed.

A three-year, large-scale marine environmental baseline study conducted from 1974 to 1977 in the eastern Gulf of Mexico resulted in an overview of the Mississippi, Alabama, Florida (MAFLA) OCS environment to 200 m (SUSIO, 1977; Dames and Moore, 1979). Analysis of water, sediments, and biota for hydrocarbons indicated that the MAFLA area is pristine, with some influence of anthropogenic and petrogenic hydrocarbons from river sources. Analysis of trace metal contamination for the nine trace metals analyzed (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc) also indicated no contamination. A decade later, the continental shelf off Mississippi and Alabama was revisited (Brooks, 1991). Bottom sediments were analyzed for high-molecular-weight hydrocarbons and heavy metals. High-molecular-weight hydrocarbons can come from natural petroleum or recent biological production as well as input from anthropogenic sources. In the case of the Mississippi-Alabama shelf, the source of petroleum hydrocarbons and terrestrial plant material is the Mississippi River. Higher levels of hydrocarbons were observed in the late spring, which coincides with increased river influx. The sediments, however, are washed away later in the year, as evidenced by low hydrocarbon values in winter months. Contamination from trace metals was not observed (Brooks, 1991).

The SAIC (1997) summarized information about water quality on the shelf from DeSoto Canyon to Tarpon Springs and from the coast to 200 m water depth. Several small rivers and the Loop Current are the primary influences on water quality in this region. Because there is very little development in this area, the waters and surface sediments are uncontaminated. The Loop Current flushes the area with clear, low-nutrient water.

More recent investigations of the continental shelf east of the Mississippi River confirm previous observations that the area is highly influenced by river input of sediment and nutrients (Jochens et al., in preparation). Hypoxia was not observed on the shelf during the three years of the study.

Deepwater

Limited information is available on the deepwater environment. Water at depths greater than 1,400 m is relatively homogeneous with respect to temperature, salinity, and oxygen (Nowlin, 1972; Pequegnat, 1983; Gallaway et al., 1988). Of importance, as pointed out by Pequegnat (1983), is the flushing time of the Gulf of Mexico. Oxygen in deepwater must originate from the surface and be mixed into the deepwater by some mechanism. If the replenishment of the water occurs over a long period of time, the addition of hydrocarbons through the discharge from oil and gas activities could lead to low oxygen and potentially hypoxic conditions in the deepwater of the Gulf of Mexico. The time scales and mechanism for maintaining the high oxygen levels in the deep Gulf are unknown.

Limited analyses of trace metals and hydrocarbons for the water column and sediments exist (Trefry, 1981; Gallaway et al., 1988). Hydrocarbon seeps are extensive throughout the continental slope and contribute hydrocarbons to the surface sediments and water column, especially in the Central Gulf (Sassen et al., 1993a and b). MacDonald et al. (1993) observed 63 individual seeps using remote sensing and submarine observations. Estimates of the total volume of seeping oil vary widely from 29,000 bbl/yr (MacDonald, 1998) to 520,000 bbl/yr (Mitchell et al., 1999). These estimates used satellite data and an assumed slick thickness. In addition to hydrocarbon seeps, other fluids leak from the underlying sediments into the bottom water along the slope. These fluids have been identified to have three origins: (1) seawater trapped during the settling of sediments; (2) dissolution of underlying salt diapirs; and (3) deep-seated formation waters (Fu and Aharon, 1998; Aharon et al., 2001). The first two fluids are the source of authigenic carbonate deposits while the third is rich in barium and is the source of barite deposits such as chimneys.

3.2. Biological Resources

3.2.1. Sensitive Coastal Environments

The coastal environments discussed here are those barrier beaches, wetlands, and submerged vegetation that might be impacted by activities resulting from the proposed actions. Geographically, the discussion covers coastal areas that range from the State of Tamaulipas, Mexico, through Alabama in the U.S. Several geologic subareas are found along this coast. Although seemingly similar biological environments occur in each of those subareas, they vary significantly. For that reason, the following environmental descriptions of this coast are organized into four geologic subareas. Those areas are (1) the barrier island complex of northern Tamaulipas, Mexico, and southern Texas; (2) the Chenier Plain of eastern Texas and western Louisiana; (3) the Mississippi River Delta complex of southeastern Louisiana; and (4) the barrier-island and Pleistocene-plain complex of Mississippi and Alabama.

The landmasses in these areas are relatively low. Some form broad flat plains with gradually, sloping topographies. Tides there are diurnal and micro-tidal (Table 3-2). Tidal influences can be seen 25-40 mi inland in some areas of Louisiana, Texas, and Alabama, due to large bay complexes, channelization, and low topographies. Wind-driven tides are often dominant over the minimal gravity tides that occur there.

3.2.1.1. Coastal Barrier Beaches and Associated Dunes

The U.S. Gulf shoreline from the Mexican border to Florida is about 1,500 km long. Ocean-wave intensities around the Gulf are generally low to moderate. These shorelines are usually sandy beaches that can be divided into several interrelated environments. Generally, beaches consist of a shoreface, foreshore, and backshore. The shoreface slopes downward and seaward from the low-tidal water line, under the water. The nonvegetated foreshore slopes up from the ocean to the beach berm-crest. The backshore is found between the beach berm-crest and the dunes, and it may be sparsely vegetated. The berm-crest and backshore may occasionally be absent due to storm activity.

The dune zone of a barrier landform can consist of a single low dune ridge, several parallel dune ridges, or a number of curving dune lines that may be stabilized by vegetation. These elongated, narrow landforms are composed of wind-blown sand and other unconsolidated, predominantly coarse sediments.

Sand dunes and shorelines conform to environmental conditions found at its site. These conditions usually include waves, currents, wind, and human activities. When Gulf waters are elevated by storms, waves are generally larger and can overwash lower coastal barriers, creating overwash fans or terraces behind and between the dunes. With time, opportunistic plants will re-establish on these flat, sand terraces, followed by the usual vegetative succession for this area. Along more stable barriers, where overwash is rare, the vegetative succession in areas behind the dunes is generally complete. Vegetation in these areas of broad flats or coastal strands consists of scrubby woody vegetation, marshes, and maritime forests. Saline and freshwater ponds may be found among the dunes and on the landward flats. Landward, these flats may grade into wetlands and intertidal mud flats that fringe the shore of lagoons, islands, and embayments. In areas where no bay or lagoon separates barrier landforms from the mainland, the barrier vegetation grades into scrub or forest habitat of the mainland.

Larger changes to barrier landforms are primarily due to storms, subsidence, deltaic cycles, longshore currents, and human activities. Barrier landform configurations continually adjust, accreting and eroding, in response to prevailing and changing environmental conditions. Landform changes can be seasonal and cyclical, such as seen with the onshore movement of sand during the summer and offshore movement during the winter, which is due to seasonal meteorological and wave-energy differences. Non-cyclical changes in landforms can be progressive, causing landform movement landward, seaward, or laterally along the coast.

Lateral movement of barrier landforms is of particular importance. As headlands and beaches erode, their sediments are transported offshore or laterally along the shoreline. Eroding headlands typically extend sand spits that may encape marshes or previously open, shallow Gulf waters. By separating inshore waters from Gulf waters and slowing the dispersal of freshwater into the Gulf, movements of barrier landforms contribute to the area and diversity of estuarine habitat along a coast. Most barrier islands around the Gulf are moving laterally to some degree. Where this occurs, the receding end of the island is typically eroding; the leading end accretes. These processes may be continuous or cyclic.

Accumulations and movements of sediments that make up barrier landforms are often described in terms of regressive and transgressive sequences. Although transgressive landforms dominate around the Gulf of Mexico, both transgressive and regressive barriers occur there. A regressive sequence deposits terrestrial sediments over marine deposits, building land into the sea, as would be seen during deltaic land-building processes. Regressive barriers have high and broad dune profiles. These thick accumulations of sand may form parallel ridges.

A transgressive sequence moves the shore landward, allowing marine deposits to form on terrestrial sediments. Transgressive coastal landforms around the Gulf have low profiles and are characterized by narrow widths; low, sparsely vegetated, and discontinuous dunes; and numerous, closely spaced, active washover channels. Landward movement or erosion of a barrier shoreline may be caused by any combination of subsidence, sea-level rise, storms, channels, groins, seawalls, and jetties. These influences are discussed under the cumulative activities scenario (Chapter 4.1.3.3). Movement of barrier systems is not a steady process because the passage rates and intensities of cold fronts and tropical storms, as well as intensities of seasons, are not constant (Williams et al., 1992).

Texas and Mexican Barrier Island Complex

The Gulf coastline of Texas is about 590 km long. The State of Tamaulipas, in northeastern Mexico, has a Gulf shoreline of about 378 km. The barrier islands of both areas are mostly accreted sediments that were reworked from river deposits, previously accreted Gulf shores, bay and lagoon sediments, and exposed seafloors (White et al., 1986). This reworking continues today as these barrier beaches and islands move generally to the southwest (Price, 1958). During the period of about 1850-1975, net coastal erosion occurred in the following three groups of counties in Texas: (1) Cameron, Willacy, and southern Kenedy; (2) northern Matagorda, Brazoria, and southern Galveston; and (3) Jefferson, Chambers, and far northern Galveston (Morton, 1982). These generalized trends seem to be continuing.

Elevations of Galveston Island and Bolivar Peninsula beach ridges generally range from 1.5 to 3 m above sea level (Fisher et al., 1972). The beaches of Galveston Island and Bolivar Peninsula are locally eroding or accreting. Accreting shorelines have a distinct beach berm and a wide back beach. Eroding beaches are relatively narrow, and the beach berm and back beach may be absent. Construction of seawalls and jetties on Galveston Island have contributed to erosion there, as discussed further in Chapter 4.1.3.3.

Padre Island is moderately regressive. It is typically 1.5-3 m above sea level and occasionally overwashed by hurricane surges. On the northern portion, some dunes may rise 6-9 m and the dune ridge is generally continuous. On the southern portion, the dune ridge is a series of short discontinuous segments. The dry winds and arid nature of this southern portion destabilize sand dunes. Sand flats and coppice dunes occupy the southern portion of the island. Any activity that reduces the sparse vegetation cover of this area initiates erosion. Vegetation on Padre Island is generally sparse, becoming more sparse on its southern portion. The vegetation largely consists of grasses and scrubby, woody growth (Brown et al., 1977; Smith, in press).

Exceptions to the above are the once regressive Matagorda Peninsula and Rio Grande Headland. The Matagorda Peninsula accreted as the Brazos-Colorado River Delta. Later, the peninsula became transgressive and the sediments were reworked to form flanking arcs of barrier sand spits. Washover channels cut the westward arc of the peninsula, forming barrier islands. The Rio Grand Headland has also become transgressive and sand spits formed to its north and south. Today, longshore drift is southerly at these sites. Their northern spits are now eroding and their southern spits are accreting.

The Chenier Plain

The Chenier Plain of eastern Texas and western Louisiana began developing about 2,800 years ago. During that period, Mississippi River Delta sediments were intermittently eroded, reworked, and carried into the Chenier Plain area by storms and coastal currents. This deposition gathered huge volumes of mud and sand, forming a shoreface that slopes very gently, almost imperceptibly, downward for a very long distance offshore. This shallow mud bottom is viscous and elastic, which generates hydrodynamic friction (Bea et al., 1983). Hence, wave energies along the barrier shorelines of the Chenier Plain are greatly reduced, causing minimal longshore sediment transport along the Chenier Plain (USDOI, GS, 1988). More recently, this shoreline has been eroding as sea level rises, converting most of this coast to transgressive shorelines.

Today, the Red River and about 30 percent of the Mississippi River are diverted to the Atchafalaya River. The diversions have increased the sediment load in the longshore currents, which generally move slowly westward along the coast.

The barrier beaches of the Chenier Plain are generally narrow, low, and sediment starved due to the natures of coastal currents and the shoreface. Here and there, beach erosion has exposed relic marsh terraces that were buried by past overwash events. West of about Fence Lake, Texas, the beach is fairly typical, being composed of shelly sand; although, it is no more than 200 ft wide. Its shoreface sediments are similar (Fisher et al., 1973).

East of Fence Lake, the shoreface contains discontinuous mud deposits among muddy sands. During low tides, extensive mudflats are exposed east and west of Fence Lake. The beach in this area is much narrower and becomes a low escarpment, where wave action cuts into the salt marsh (Fisher et al., 1973). In the vicinity of Louisiana’s Constance Beach and Peveto, the rapidly eroding beach may be as much as 60 ft wide, where it exists. In this vicinity, erosion threatens Louisiana State Highway 82 and a few houses. In these more rapidly eroding areas, the beach is replaced by rip-rap and bulkheads (Mann and Thompson, 2001). In 1988, the U.S Geological Survey reported that general shoreline retreat along the Chenier Plain had been three or more meters per year. Since then, a series of offshore wave breaks have been placed from Constance Beach to Holly Beach, Louisiana, to reduce erosion and to retain sediments. These circumstances are discussed in greater detail in Chapter 4.1.3.3.

The dune ridges of the Chenier Plain’s shoreline are generally well vegetated. Their elevations along the Texan segment are generally less than 5 ft (Fisher et al., 1973). Transects taken along the beach in the vicinity of Oceanview Beach to Holly Beach indicate that the dune ridge ranged between 7 and 12 ft National Geodetic Vertical Depth (NGVD). For comparison, the high-water shoreline position during October 1992 through July 1994 was estimated to be fairly stable, at about 3.5 ft NGVD (Byrnes and McBride, 1995).

The Mississippi River Delta Complex

Most barrier shorelines of the Mississippi River Delta in Louisiana are transgressive and trace the seaward remains of a series of five abandoned deltas. The Mississippi River is channelized through the Belize Delta, more commonly known as the Birdfoot Delta. Channelization isolated the river from most of this sixth delta, except near the distributary mouths. There, a small fraction of the river’s sediment load is contributed to longshore currents for building and maintaining barrier shores. The bulk of river sediments are deposited in deep water, where they cannot be reworked and contribute to the longshore sediment drift. Most of southeastern Louisiana's barrier beaches are composed of medium to coarse sand.

The shorefaces of the Mississippi River Delta complex generally slope very gently seaward, which reduces wave energies at the shorelines. Mud flats are exposed during very low tidal events. The slope here is not as shallow as that found off the Chenier Plain. The steepest shoreface of the delta is found at the Caminada-Moreau Coast, where the greatest rates of erosion are seen. At this site, the long shore currents split to the east and west, which removes sand from the area without replenishing the area (Wolfe et al., 1988; Wetherell, 1992; Holder and Lugo-Fernandez, 1993).

Regressive shorelines do occur in Louisiana's deltaic region. The diversion of the Red River and about 30 percent of the Mississippi River to the Atchafalaya River has allowed transport of large volumes of sediment into shallow Atchafalya Bay. There, inland deltas are forming at the mouths of that river and Wax Lake Outlet, which are discussed more fully under Chapter 3.2.1.2. Recent satellite photography of these deltas reveal that dredge-disposal islands were constructed off Point au Fer in very shallow water (3-5 ft) at the mouth of Atchafalaya Bay. These islands and the surrounding shallows are the foundations for a future barrier shoreline in this area, if the Atchafalaya River Delta continues to build seaward as expected.

Smaller shoreline regressions also occur as a result of jetties located on the eastern end of Grand Isle, the western end of Caminada-Moreau Beach, Empire navigational canal, and elsewhere. The circumstances of these situations are discussed more completely in Chapter 3.2.1.2.

Most dune zones of the Mississippi River Delta contain low, single-line dune ridges that may be sparsely to heavily vegetated. Generally in this area, the vegetation on a dune ridge gets denser as the time between storms lengthens. The dune zone of the Chandeleur Islands is larger and more complex. Boyd and Penland (1988) reported that elevations of the Chandeleur Islands ranged between less than 1 m and 8 m MSL (above mean sea level). Since then, the hurricanes of the 1990's greatly lowered these elevations, which are slowly recovering. In 1997 the Chandeleur Islands contained about 1,930 ha of land, most of which was beach and dune complex (USDOI, GS, 1998).

Boyd and Penland (1988) reported that 52 percent of the Caminada-Moreau Coast had a vegetated, dune ridge of less than 1 m MSL and that the elevation of the remaining length ranges up to 3 m MSL. The mean water-level threshold for overwashing 75 percent of that beach is 1.42 m MSL. They estimated that this threshold is achieved about 15 times a year, on average. Mean water elevations exceeding 2.5 m MSL occur once every 2 years (Richie and Penland, 1985).

Boyd and Penland (1988) estimated that storms raise mean water levels 1.73-2.03 m above mean sea level 10-30 times per year. Under those conditions, the following would be over washed: 67 percent of Timbalier Island; 100 percent of Isles Dernieres and the Barataria Bay Barriers (excluding Grand Isle); and 100, 89, and 64 percent of the southern, central, and northern portions of the Chandeleur Islands, respectively.

Shell Key is an emerged barrier feature that varies greatly from the others around the Delta. It is located south of Marsh Island, Louisiana, at the mouth of Atchafalaya Bay, and is composed almost entirely of oyster-shell fragments. It is found amid extensive shell reefs, which are part of the Shell Keys National Wildlife Refuge. This dynamic, minimally vegetated island builds and wanes with passing storms. In 1992 and 1999, Hurricane Andrew and Hurricane Francis reduced the island to little more than a shoal that largely submerges under storm tides. The shallow, submerged shell reefs around Shell Key also serve as barrier features. Located on the other side of the bay's mouth and to the southeast, the Point au Fer Shell Reefs were commercially dredged for shells, and no longer exist (USDOI, FWS, 2001; Schales and Soileau, personal communication, 2001)

Mississippi and Alabama Coasts

The Dog Keys define the Mississippi Sound of Mississippi and Alabama. Mississippi has about 54.6 km of barrier beaches on these islands (USDOI, FWS, 1999). Dauphin Island represents about another 12 km. This relatively young group of islands was formed 3,000-4,000 years ago as a result of shoal-bar accretion (Otvos, 1979). They are separated by wide passes with deep channels. Shoals are typically adjacent to these barriers. Generally, these islands are regressive and stable in size as they migrate westwardly in response to the predominantly westward-moving longshore currents.

These islands generally have high beach ridges and prominent sand dunes. Although overwash channels do not commonly occur, the islands may be overwashed during strong storms. The islands are well vegetated among and behind the dunes and around ponds. Southern maritime climax forests of pine and palmetto are found behind some of their dune fields.

Dauphin Island, Alabama, is the exception to the above description. It is essentially a low-profile transgressive barrier island, except for a small, eroding, Pleistocene core at its eastern end. The western end is a Holocene spit that is characterized by small dunes and many washover fans, exposed marsh deposits, and tree stumps exposed in the surf zone.

Pelican Island, Alabama, is a vegetated sand shoal, located Gulfward of Dauphin Island. Southeasterly of that island is Sand Island, which is little more than a shoal. These barrier islands are parts of Mobile Bay's ebb-tidal delta. As such, they continually change shape under storm and tidal pressures. Their sands generally move northwesterly into the longshore drift, nourishing beaches down drift. These sediments may also move landward during flood tides (Hummell, 1990).

The Gulf Shores region of Alabama extends from Mobile Point eastward to the Florida boundary, a distance of about 50 km (Smith, 1984). It has the widest beaches and largest dune system among the barrier beaches discussed.

3.2.1.2. Wetlands

According to the U.S. Dept. of the Interior (Dahl, 1990; Henfer et al., 1994), during the mid-1980's, 4.4 percent of Texas (3,083,860 ha) (Henfer et al., 1994), 28 percent of Louisiana (3,557,520 ha), 14 percent of Mississippi (17,678,730 ha), and 8 percent of Alabama (1,073,655 ha) were considered wetlands. During the prior 10 years, these states' wetland areas decreased by 1.6-5.6 percent.

Wetland habitats found along the Central and Western Gulf Coast include fresh, intermediates, brackish, and saline marshes; mud and sand flats; and forested wetlands of mangrove swamps, cypress-tupelo swamps, and bottomland hardwoods. Coastal wetland habitats occur as bands around waterways and as broad expanses. Saline and brackish habitats support sharply delineated, segregated stands of single plant species. Fresh and very low salinity environments support more diverse and mixed communities of plants. The plant species that occur in greatest abundance vary greatly around the Gulf. For those reasons, interested readers are referred to ecological characterization and inventory studies conducted by the FWS, in cooperation with other agencies; the Texas Bureau of Economic Geology; and other researchers (Gosselink et al., 1979; Gosselink, 1984; Smith, 1984; Fisher et al., 1972 and 1973; Brown et al., 1976 and 1977; Stout et al., 1981).

The importance of coastal wetlands to the coastal environment has been well documented. See the above listed characterization and inventory studies. High organic productivity and efficient nutrient recycling are characteristic of coastal wetlands. They provide habitat for a great number and wide diversity of resident plants, invertebrates, fishes, reptiles, birds, and mammals. Marsh environments are particularly important nursery grounds for many economically important fish and shellfish juveniles. The marsh edge, where marsh and open water come together, is particularly important for its higher productivity and greater concentrations of organisms. Emergent plants produce the bulk of the energy that supports salt-marsh dependent animals. Freshwater-marsh environments generally contain a much higher diversity of plants and animals than do those of saline marshes.

Gulf coastal wetlands also support the largest fur harvest in North America, producing 40-65 percent of the nation's yearly total in Louisiana (Olds, 1984). Gulf coastal wetlands support over two-thirds of the Mississippi Flyway wintering waterfowl population and much of North America's puddle duck population.

Texas Barrier Islands and Tamaulipas Coastal Wetlands

Landward of the barrier beaches of Texas, estuarine marshes largely occur as continuous and discontinuous bands around bays, lagoons, and river deltas. Broad expanses of emergent wetland vegetation do not commonly occur south of Baffin Bay because of the arid climate and hypersaline waters. In the vicinity of southern Padre Island, marshes are minimal and unstable, compared to the more northern Gulf. In Tamaulipas, marshes behind the barrier islands are even less abundant than seen in the vicinity of Padre Island. Dominant salt-marsh plants in southern regions include more salt-tolerant species such as *Batis maritima* and glasswort (*Salicornia sp.*).

Brackish marshes occur in less saline, inland areas and are divided into frequently and infrequently flooded marshes. Infrequently flooded marshes contain an assemblage of plants that are much more tolerant of dry conditions. Freshwater marshes in Texas occur inland above tidally delivered saline waters, in association with streams, lakes, and catchments. Broken bands of black mangroves (*Avicennia germinans*) also occur in this area (Brown et al., 1977; White et al., 1986; Smith, in press).

Wind-tidal flats of mud and sand are mostly found around shallow bay margins and in association with shoals. As one goes farther south from Corpus Christi and into Tamaulipas, flats increasingly replace lagoonal and bay marshes. Laguna Madre of Texas is divided into northern and southern parts by the wind-tidal flats of the Land-Cut Area, just south of Baffin Bay. The Intracoastal Waterway is dredged through this area, as are a series of well access channels. Dredging has caused topographic and vegetative changes among the flats of Laguna Madre.

Frequently flooded flats usually remain moist and may have mats of blue-green algae and an area-specific assemblage of invertebrates. Infrequently flooded flats are at higher elevations where only tides that are driven by strong wind can flood them. These are better drained and much dryer. Higher tidal flats remain barren because of the occasional saltwater flooding and subsequent evaporation that raises salt concentrations in the soil. This inhibits most plant growth; some salt-marsh plants that are tolerant of dry conditions may be found there. Some higher flats are nontidal, barren fan deltas and barren channel margins along streams. The salt concentrations of these soils are often elevated also (Brown et al., 1977; White et al., 1986; Smith, in press).

Inland beaches of sand and shells are found along the shores of bays, lagoons, and tidal streams. The structure of these beaches is similar to but much narrower and smaller in scale than barrier beaches. Compared to the sand beaches, shell features are typically stacked to higher elevations by storm waves and are generally more stable.

Few freshwater swamps and bottomland hardwoods occur in the general vicinity of OCS-related service bases and navigational channels of the Texas barrier island area. In the southern third of this area, they are nonexistent (Brown et al., 1977; White et al., 1986).

Chenier Plain

Beginning about 2,800 years ago and as sea level dropped during the last ice age, sediments from the Mississippi River and its delta were intermittently reworked and deposited by storms and coastal currents, forming the Chenier Plain between Port Bolivar, Texas, and Atchafalaya Bay in Louisiana. As the area filled in, a series of shell and sand ridges were formed parallel or oblique to the present-day Gulf Coast and were later abandoned as sea level continued to fall. Mudflats formed between the ridges when localized hydrologic and sedimentation patterns favored deposition there. This intermittent deposition isolated entrenched valleys from the Gulf, forming large lakes such as Sabine, Calcasieu, White, Grand, and others (Gosselink et al., 1979; Fisher et al., 1973). As a result, few tidal passes are found along this coast as compared to central Texas and eastern Louisiana. This reduces the tidal movement of saline waters.

Because of the structure of the Chenier Plain and its beaches, salt marshes are not as widely spread there as elsewhere in the northern Gulf. Generally in this area, salt marshes front the Gulf directly and are frequently submerged by tides and storms. Hence, they are considered high-energy environments, as compared to most vegetated wetlands.

Brackish and intermediate salinity marshes are dominant in estuarine areas of the Chenier Plain. They are tidal, although wind-driven tides are more influential and occasionally inundate these areas. Since salinity in this area ranges broadly, these habitats support a mix of salt and salt-tolerant freshwater plants, although marsh-hay cordgrass is generally dominant. These habitats are the most extensive and productive in coastal Louisiana.

Plant communities of freshwater marshes are among the most diverse of sensitive coastal environments. Annuals have a much greater presence in freshwater marshes than in estuarine areas. Dominance often changes from season to season as a result of year-round seed-germination schedules. Freshwater wetlands are extensive in the Chenier Plain due to the abundant rainfall and runoff coupled with the ridge system that retains freshwater and restricts the inflow of saline waters. Tidal influences are generally minimal in these areas, although strong storms may inundate the area. Hence, detritus is not as readily exported and accumulates there, supporting additional plant growth. Freshwater marsh plants are generally more buoyant than estuarine plants. In areas where detritus collects thickly, marsh plants may form floating marshes, referred to as "flotants." Flotants generally occur in very low-energy environments. They are held together by surrounding shorelines and a weave of slowly deteriorating plant materials and living roots.

Forested wetlands are not very common in the Chenier Plain. They only occur in the flood plain regions of major streams, along the northern margin of this area. There, cypress-tupelo swamps grade through stands of blackwillow to bottomland hardwoods.

Mississippi River Delta Complex

Mississippi River Delta Complex forms a plain that is composed of a series of overlapping riverine deltas that have extended onto the continental shelf over the past 6,000 years. Wetlands on this deltaic plain are the most extensive of those within this EIS's area of attention.

Sparse stands of black mangrove are found here and there, in the highest salinity areas of the Barataria and Terrebonne Basins. Extensive salt and brackish marshes are found throughout the southern half of the plain and east of the Mississippi River. Further inland, extensive intermediate and fresh water marshes are found. East of the Mississippi River and south of Lake Pontchartrain, Louisiana, very few intermediate and freshwater wetlands were found until the Caernarvon Freshwater Diversion was intermittently put into action in 1993. In freshwater areas, cypress-tupelo swamps are found flanking the natural levees and in areas that are impounded by dredged materials, levees, or roads. Bottomland hardwoods are found on the numerous natural levees and in drained levee areas

Except for leveed areas and the delta and basin of the Atchafalaya River, all of these deltas are generally experiencing succession towards wetter terrestrial and deeper water habitats. This is due to deltaic abandonment and human actions and their ensuing erosion. Most of these wetlands are built upon highly organic soils, which are easily eroded, compacted, and oxidized. These problems are discussed in Chapter 4.1.3.3.

Two active deltas are found in this area. The more active is in Atchafalaya Bay, at the mouths of the Atchafalaya River and its distributary, Wax-lake Outlet. Because the Red River and about thirty percent of the Mississippi River have been diverted to the Atchafalaya River, large volumes of sediment are being delivered to that shallow bay. As a result, extensive freshwater marshes, swamps, and bottomland hardwoods are found in this river basin. Relatively few estuarine marshes are found there.

The less active delta is at the mouth of the Mississippi River, which is referred to as the Belize or Birdfoot Delta. The Mississippi River has been channelized through most of this delta, which greatly reduced the volume of sediments that it contributes to the delta and longshore currents near the mouths of its distributaries. A few man-made diversions have been installed that are designed to deliver water rather than sediments to this delta. See Chapter 4.1.3.3 for a fuller description of these circumstances.

Mississippi and Alabama

Estuarine marshes around Mississippi Sound and associated bays occur in discontinuous bands. The most extensive wetland areas in Mississippi occur in the eastern Pearl River delta near the western border of the State and in the Pascagoula River delta area near the eastern border of the State. Mississippi's wetlands seem to be more stable than those in Louisiana and Alabama, perhaps reflecting the more stable substrate, more active and less disrupted sedimentation patterns in wetland areas, and the occurrence of only minor canal dredging and development.

Alabama has approximately 118,000 ac of coastal wetlands, of which approximately 75,000 ac are forested, 4,400 ac are freshwater marsh, and 35,400 ac are estuarine marsh (Wallace, 1996). Most coastal wetlands in Alabama occur on the Mobile River delta or along the northern Mississippi Sound.

3.2.1.3. Seagrass Communities

Three million hectares of submerged seagrass beds are estimated to exist in exposed, shallow coastal waters of the northern Gulf of Mexico. An additional 166,000 ha are found in protected, natural embayments and are not considered exposed to OCS impacts. The area off Florida, in the Eastern Planning Area, contains approximately 98.5 percent of all coastal seagrasses in the northern Gulf of Mexico; Texas and Louisiana contain approximately 0.5 percent. Mississippi and Alabama have the remaining 1 percent of seagrass beds.

Seagrass beds grow in shallow, relatively clear and protected waters with predominantly sand bottoms. Their distribution depends on an interrelationship among a number of environmental factors that include temperature, water depth, turbidity, salinity, turbulence, and substrate suitability. Primarily because of low salinity and high turbidity, robust seagrass beds and the accompanying high diversity of marine species are found only within a few scattered, protected locations in the Western and Central Gulf of Mexico. Inshore seagrasses provide important habitat for immature shrimp, black drum, spotted sea trout, juvenile southern flounder, and several other fish species; and they provide a food source for several species of wintering waterfowl.

Seagrasses in the WPA are widely scattered beds in shallow, high-salinity coastal lagoons and bays. The most extensive seagrass beds are found in both the Upper and Lower Laguna Madre along the Texas coast, as well as Baffin Bay. In the Texas Laguna Madre, seagrass meadows are the most common submerged habitat type. Although permanent meadows of perennial species occur in nearly all bay systems along the Texas Gulf Coast, most of the State's seagrass cover (79%) is found in the Laguna Madre (Pulich, 1998), with seagrasses currently covering about 243 km^2 in the upper portion of the Laguna Madre (Quammen and Onuf, 1993). Seagrasses are largely excluded from bays north of Pass Cavallo where rainfall and inflows are high and salinity's average less than 20 ppt, as well as the upper, fresher portions of most estuaries. Seagrasses in the Laguna Madre constitute a unique resource that cannot be duplicated elsewhere on the Texas coast (Withers, 2001). Lower-salinity, submerged beds of aquatic vegetation are found inland and discontinuously in coastal lakes, rivers, and the most inland portions of some coastal bays.

The turbid waters and soft, highly organic sediments of Louisiana's estuaries and offshore areas limit widespread distribution of higher salinity seagrass beds. Consequently, only a few areas in offshore Louisiana, mostly in Chandeleur Sound, support seagrass beds. In Mississippi and Alabama, seagrasses occur within the Mississippi Sound.

The distribution of seagrass beds in coastal waters of the Western and Central Gulf have diminished during recent decades. Primary factors believed to be responsible include dredging, dredged material disposal, trawling, water quality degradation, hurricanes, a combination of flood protection levees that have directed freshwater away from wetlands, saltwater intrusion that moved growing conditions closer inland, and infrequent freshwater diversions from the Mississippi River into coastal areas during flood stage.

3.2.2. Continental Shelf Benthic Resources

Seafloor (benthic) habitats, including live-bottom areas, topographic features, and deepwater benthic communities, are essential components of the overall offshore community assemblage in the Gulf of Mexico. The benthic resources of the continental shelf are discussed in Chapter 3.2.2.. Deepwater benthic resources are discussed in Chapter 3.2.3.

The pelagic offshore water-column biota contains primary producers (phytoplankton and bacteria—90 percent of the phytoplankton in the northern Gulf of Mexico is constituted by diatoms), secondary producers (zooplankton), and consumers (larger marine species including fish, reptiles, cephalopods, crustaceans, and marine mammals). The zooplankton consists of holoplankton (organisms for which all life stages are spent in the water column, including protozoans, gelatinous zooplankton, copepods, chaetognaths, polychaetes, and euphausids) and meroplankton (mostly invertebrate and vertebrate organisms for which larval stages are spent in the water column, including polychaetes, echinoderms, gastropods, bivalves, and fish larvae and eggs). Planktonic primary producers drift with currents, whereas zooplankton moves by swimming. The species diversity, standing crop, and primary productivity of offshore phytoplankton are known to fluctuate much less than their coastal counterparts as the offshore phytoplankton are less subject to changes of salinity, nutrient availability, vertical mixing, and zooplankton predation. In general, the diversity of pelagic planktonic species generally decreases with decreased salinity, and biomass decreases with distance from shore. Temperature, salinity, and nutrient availability limit the geographical and vertical ranges of plankton and consumers. The fish species of the Gulf are temperate, with incursions of subtropical Caribbean faunas. Gulf fish species exhibit seasonal distribution and abundance fluctuations that are probably largely related to oceanographic conditions.

Another essential component of the offshore environment is the neuston, which is composed of organisms living at the air-seawater interface. Significant components of the neuston are copepods, floating *Sargassum* algae (also known as "*Sargassum* mats"), and the organisms associated with the

Sargassum. As many as 100 different animal species can be found in the floating *Sargassum* in the Gulf. These species include mostly hydroids and copepods, but also contain fish, crabs, gastropods, polychaetes, bryozoans, anemones, and sea spiders. The majority of these organisms depend on the presence of the *Sargassum* algae. *Sargassum* alga rafts potentially constitute long-term havens for young sea turtles, which drift with these floating ecosystems as they feed off their living organisms, possibly for several years.

Shelf phytoplankton and zooplankton are more abundant, more productive, and seasonally more variable than the deep Gulf plankton. This is related to salinity changes, greater nutrient availability, increased vertical mixing, and different zooplankton predation in the shelf environment.

The benthos of the shelf has both floral and faunal components; floral representatives include bacteria, algae, and seagrasses. The abundance of benthic algae is limited by the scarcity of suitable substrates and light penetration. In exceptionally clear waters, benthic algae, especially coralline red algae, are known to grow in water depths to at least 180 m. Rezak et al. (1983) recorded algae from submarine banks off Louisiana and Texas. Offshore seagrasses are not conspicuous in the Central and Western Gulf; however, fairly extensive beds may be found in estuarine areas behind the barrier islands throughout the Gulf.

Benthic fauna include infauna (animals that live in the substrate, including mostly burrowing worms, crustaceans, and mollusks) and epifauna (animals that live on or are attached to the substrate; mostly crustaceans, as well as echinoderms, mollusks, hydroids, sponges, and soft and hard corals). Shrimp and demersal fish are closely associated with the benthic community. Substrate is the single most important factor in the distribution of benthic fauna (densities of infaunal organisms increase with sediment particle size) (Defenbaugh, 1976), although temperature and salinity are also important in determining the extent of faunal distribution. Depth and distance from shore also influence the benthic faunal distribution (Defenbaugh, 1976). Lesser important factors include illumination, food availability, currents, tides, and wave shock. Indeed, the density of offshore infaunal organisms has been found to be greater during the spring and summer as compared to the winter (Brooks, 1991).

In general, the vast majority of bottom substrate available to benthic communities in the Central and Western Gulf consists of soft, muddy bottoms; the benthos here is dominated by polychaetes. Benthic habitats on the continental shelf at most risk to potential impacts from oil and gas operations are topographic features and the pinnacle trend, live-bottom communities (Chapter 3.2.2).

3.2.2.1. Continental Slope and Deep Sea

The continental slope is a transitional environment influenced by processes of both the shelf and the abyssal (deep sea) Gulf (>975 m). This transitional character applies to both the pelagic and the benthic realms.

The deep-sea area (>800 m) of the northern Gulf of Mexico is much less known than the shelf (<150 m). Observed biotal differences in the deep ecosystem of the Gulf justify referring to the Western Gulf (which includes both the WPA and CPA) as the "true" Gulf and to the Eastern Gulf (which includes the EPA) as a divergence of the "Tropical Western Atlantic" (Pequegnat, 1983; LGL Ecological Research Associates, Inc. and Texas A&M University, 1986).

The highest values of surface primary production are found in the upwelling area north of the Yucatan Channel and in the DeSoto Canyon region. In general, the Western Gulf is more productive in the oceanic region than is the Eastern Gulf. It is generally assumed that all the phytoplankton is consumed by the zooplankton, except for brief periods during major plankton blooms. The zooplankton then egests a high percentage of their food intake as feces that sink toward the bottom. Most of the herbivorous zooplankton are copepods, calanoids being the dominant group (Pequegnat, 1983).

Compared to the shelf, there is less plankton on the slope and in the deep Gulf. In addition, some of the planktonic species are specifically associated with either the slope or the deep sea. The biomass of plankton does not appear to be affected by seasonal changes. Some east-west variations noted among diatom species have been attributed to the effects of different watermasses, i.e., normal Gulf waters versus those influenced by the Mississippi River (Pequegnat, 1983).

The topographic and physical oceanographic conditions at East Breaks in the Western Gulf support nutrient-rich upwelling, which may significantly contribute to recreational billfishing in the area (as reported by the National Marine Fisheries Service (NMFS)) as well as the year-round presence of large pelagic filter feeders such as whale sharks and manta rays (observations from East Breaks production platforms 110 and 165).

The 450-m isobath defines the truly deep-sea fauna. The aphotic zone at and beyond these depths (below the euphotic zone and extending to within a meter off the bottom) represents a huge mass of water. In these sunlight-deprived waters, photosynthesis cannot occur, and processes of food consumption, biological decomposition, and nutrient regeneration occur in cold and dark waters. The lowermost layer containing the last meter of water off the bottom and the bottom itself constitute the benthic zone. This zone is a repository of sediments where nutrient storage and regeneration take place in association with the solid and semisolid substrate (Pequegnat, 1983).

Most of the benthic fauna found on the deep slope and abyssal plain are endemic to those depths and have been grouped into seven faunal assemblages by Pequegnat (1983) and confirmed by LGL Ecological Research Associates, Inc. and Texas A&M University (1986):

> The Shelf/Slope Transition Zone (150-450 m) is a very productive part of the benthic environment. Demersal fish are dominant, many reaching their maximum populations in this zone. Asteroids, gastropods, and polychaetes are common.
>
> The Archibenthal Zone has two subzones. The Horizon A Assemblage is located between 475 and 750 m. Although less abundant, the demersal fish are a major constituent of the fauna, as are gastropods and polychaetes. Sea cucumbers are more numerous. The Horizon B Assemblage, located at 775-950 m, represents a major change in the number of species of demersal fish, asteroids, and echinoids, which reach maximum populations here. Gastropods and polychaetes are still numerous.
>
> The Upper Abyssal Zone is located between 975 and 2,250 m. Although the number of species of demersal fish drops, the number that reach maximum populations dramatically increases. This indicates a group uniquely adapted to the environment. Sea cucumbers exhibit a major increase, and gastropods and sponges reach their highest species numbers here.
>
> The Mesoabyssal Zone, Horizon C (2,275-2,700 m) exhibits a sharp faunal break. The number of species reaching maximum populations in the zone drops dramatically for all taxonomic groups.
>
> The Mesoabyssal Zone, Horizon D Assemblage (2,725-3,200 m) coincides with the lower part of the steep continental slope in the Western Gulf. Since the Central Gulf is dominated at these depths by the Mississippi Trough and Mississippi Fan, the separation of Horizon C and D assemblages is not as distinct in the Central Gulf. The assemblages differ in species constitution.
>
> The Lower Abyssal Zone (3,225-3,850 m) is the deepest of the assemblages. Megafauna is depauperate. The zone contains an assemblage of benthic species not found elsewhere.

3.2.2.2. Live-Bottom (Pinnacle Trend) Resources

The northeastern portion of the Central Gulf of Mexico exhibits a region of topographic relief, known as the “pinnacle trend,” at the outer edge of the Mississippi-Alabama shelf between the Mississippi River and DeSoto Canyon. The pinnacles appear to be carbonate reefal structures in an intermediate stage between growth and fossilization (Ludwick and Walton, 1957). The region contains a variety of features from low-relief rocky areas to major pinnacles, as well as ridges, scarps, and relict patch reefs. The heavily indurated pinnacles provide a surprising amount of surface area for the growth of sessile invertebrates and attract large numbers of fish. Additional hard-bottom features are located nearby on the continental shelf, outside the actual pinnacle trend.

The features of the pinnacle trend offer a combination of topographic relief, occasionally in excess of 20 m, and hard substrate for the attachment of sessile organisms and, therefore, have a greater potential to support significant live-bottom communities than surrounding areas on the Mississippi-Alabama Shelf. This potential to support live-bottom communities has made these features a focus of concern and discussion. The species composition of the pinnacle trend has been compared to the Antipatharian Zone and Nepheloid Zone described by Rezak and Bright (1978) and Rezak (CSA, 1985). The following description of the pinnacle-trend region is found in the Mississippi-Alabama Continental Shelf Ecosystems Study: Data Summary and Synthesis, as described by Brooks (1991).

> Biological assemblages dominated by tropical hard bottom organisms and reef fishes occupy a variety of topographic features that exist between 53 and 110 m in the northeastern Gulf of Mexico between the Mississippi River and DeSoto Canyon. The origins of the carbonate features vary. Some are small, isolated, low to moderate [relief] reefal features or outcrops of unknown origin. Some appear to be hard substrates exposed by erosion during sea level still-stands along late Pleistocene shorelines. Others appear to be small reefs that existed near these shorelines. The largest reefal features appear to have been offshore reefs. The structure of the summits of some reefs may also have been modified by Holocene erosional events following their initial period of growth (namely, the flat-topped reefs). Most appear to be deteriorating under the influence of bioerosional processes. Hard bottoms and associated organisms are evident on at least two salt domes within 50 km of the Mississippi River Delta.
>
> The hermatypes that contributed to the development of these structures probably included coralline algae, reef-building corals, bryozoans, foraminiferans, and molluscs, among others. Present-day production of calcium carbonate is probably limited to an impoverished calcareous alga population on features cresting above 78 m (shallower in most areas). Features below this depth can most likely be considered completely drowned reefs.
>
> Present-day biological assemblages on features in the Northeastern Gulf are dominated by suspension feeding invertebrates. Populations are depauperate on features of low topography, those in habitats laden with fine sediments, and at the base of larger features (where resuspension of sediments limits community development). On larger features the diversity and development of communities appears to depend on habitat complexity; that is, the number of habitat types available to hard bottom organisms, and to some extent, the distance from the Mississippi River Delta. On reefs containing extensive reef flats on their summits, there are rich assemblages distinguished by a high relative frequency of sponges, gorgonian corals (especially sea fans), crinoids, and bryozoans. Due to the generally accordant depth of flat-topped reefs (62-63 m), coralline algae are also in abundance. Other organisms on reef flats include holothurians, basket stars, and myriads of fish (mostly, *Holanthias martinicensis* [roughtongue bass*], Hemanthias aureorubens* [streamer bass], *Rhomboplites aurorubens* [vermilion snapper]). On reefs lacking this reef flat habitat, as well as on reef faces of flat-topped features, the benthic community is characterized by a high relative abundance of ahermatypic corals (both solitary and colonial scleractinians). Other frequently observed organisms on these rugged, often vertical reef faces include crinoids, gorgonians, sea urchins, and basket stars. Among other species, dense schools of *H. martinicensis*, *H. aureorubens* (streamer bass) and *Paranthias furcifer* (creole-fish) often occupy their summits.
>
> Biological abundance and species diversity increase in relation to the amount of solid substrate exposed and to the variety of habitats available. Thus, low biological abundance and diversity characterize low relief features 2 m high. Features of intermediate relief (2-6 m high) may exhibit low or high abundance and diversity depending upon habitat complexity. High relief features (>6 m) have dense and diverse biotas whose composition varies with habitat type (i.e., flat reef tops vs. ragged reef sides). Depth in the water column appears not to play a major role in determining species composition except in the case of coralline algae, which have not been encountered

> below a depth of 78 m. Since most of the major species are suspension feeders, susceptibility to sedimentation does appear to limit species composition. Areas closest to the Mississippi River Delta are most affected, and this influence extends eastward for up to 115 km (70 miles) from the Delta. Living hermatypic corals have not been observed on topographic features of the Mississippi-Alabama shelf.

In assessing the overall health of the pinnacle trend live bottoms; Brooks (1991) concludes the following:

> Human impact in these environments appears to be minimal. Discarded debris or lost fishing gear (such as longlines), though present at many sites, was not abundant, and therefore poses little threat to the environment. Cables and lines can affect shallower reef communities, but probably have little impact at these depths once they become tangled on or lodged against reef structures. Fishing pressure on these relatively small features may reduce the population of the larger, commercially important species, and may explain the frequency of smaller individuals of unprofitable species on heavily fished reefs.

Continental Shelf Associates, Inc. (CSA, 1992a) investigated another portion of the Mississippi-Alabama continental shelf west and north of the areas investigated by Brooks. Three types of hard-bottom features were identified for biological characterization:

(1) pinnacle features present in approximately 80- to 90-m water depths;

(2) deepwater pinnacles and associated hard bottom located in approximately 110- to 130-m water depths; and

(3) suspected low relief, hard-bottom features in the central and eastern portions of the upper Mississippi-Alabama shelf in water depths shallower than 75 m. Although the CSA biological investigations were fairly limited, they did study several significant topographic features.

Shinn et al. (1993) investigated an exploratory drill site in Main Pass Block 255. The drill site was located at 103-m water depth and was adjacent to a 4- to 5-m high rock pinnacle. The pinnacle feature had been impacted by drill muds and cuttings approximately 15 months prior to the investigation.

In 1994, DelMar Operating Inc. re-investigated the disturbed site in Main Pass Block 255. Their findings (DelMar Operating, Inc., 1994) are summarized below:

> Locally the 330 ft (100 m) isobath appears to be the lower limit of any exposed carbonate material, regionally, the 390 ft (120 m) isobath appears to be the lower limit regardless of pinnacle or mesa-like characteristics. Associated with the mesa-like features are carbonate RLM [reef-like mounds]. These RLM are typically less than 20 ft in length, 3 ft in height, and 4 ft in breadth.
>
> Throughout the area north and east of the existing template, the slope trends are locally interrupted by several RLM. The most significant seafloor feature in the site-specific area is the carbonate material at the edge of the mesa-like feature and the moderate slope break that it defines. Within this zone, several RLM can be identified sitting above the general local bathymetric trend. Current analysis of the RLM and the mesa-like features located throughout the region indicate that all of these features are believed to be more common than originally mapped.

A four-year study (1996-2000) characterizing and monitoring carbonate mounds on the Mississippi/Alabama outer continental shelf (OCS) (Table 3-3) was recently completed by Continental Shelf Associates, Inc. and the Geochemical and Environmental Research Group (GERG) of Texas A&M University (TAMU) for the U.S. Geological Survey (USGS), Biological Resources Division (CSA and GERG, 2001). Five of the nine sites investigated during the four-year project are located in the Central

Planning Area of the Gulf of Mexico and could potentially be affected by this combined lease sale (Table 3-3); the remaining 4 sites are outside the lease sale area and will not be affected.

The five areas investigated by CSA and GERG that are included in this multisale EIS are described as follows:

- Site 5 includes high relief with a tall, flattop mound near its center and a lower mound at its southwestern edge; a horseshoe shaped (100-m base diameter), medium-profile, flattop structure, with 8-m maximum relief and a base depth of 77 m (Figure 3-3). A fine sediment veneer occurred on all horizontal rock surfaces and was particularly evident on the top of the feature, filling all depressions. This pinnacle feature is known as Double-Top Reef and belongs to the shallow pinnacle trend in the central and northeastern Gulf of Mexico.

  There are distinct assemblages of organisms in different locations on these features. Organisms found on top of the large feature were family *Stenogorgiinae, Swiftia exserta*, *Stichopathes lutkeni*, *Antipathes* spp., *Bebryce cinera/grandis*, *Ctenocella* (*Ellisella*) spp., *Hypnogorgia pendula*, and other unidentified gorgonian corals. Hermatypic as well as ahermatypic corals were sparsely distributed on the top interior probably due to heavy accumulations of fine sediments. *Rhizopsammia manuelensis* was the dominant species on almost all surfaces of the smaller mounds associated with the feature. Other species found on the vertical face of the main feature and adjacent mounds included *Madracis/Oculina* sp., *Madrepora carolina*, *Antipathes* spp., and *Stichopathes lutkeni*. Also present were the sea urchins *Stylocidaris affinis* and *Diadema antillarum*, a few unidentified sponge species, and small colonies of bryozoans.

- Site 6 is a low-relief site covering part of a large, carbonate hardground consisting of extensive areas of low-relief rock features. The features range up to about 1 m in height on a relatively flat seafloor and covered with a thin layer of fine sediments.

  There was a low-diversity biological community observed on these low-relief features. The most noticeable taxa include *Bebryce cinerea/grandis*, *Thesea* spp., *Ctenocella* (*Ellisella*) spp., *Antipathes*, and *Stichopates lutkeni*. *Rhizopsammia manuelensis* was relatively common on the few features with more than 1 m of relief, and *Madracis/Oculina* sp. and *Madrepora carolina* were also occasionally observed.

- Site 7 is a high-relief site located on a large, flat top mound. Known as "Alabama Alps," this pinnacle feature forms the northwestern terminus of a northwest to southeast aligned ridge and pinnacle arc paralleling the shelf edge (Figure 3-3) (USDOI, MMS, 2000a). The sides of the feature range from nearly vertical walls stepping down to the seafloor to large attached monolithic structures that decrease in height farther from the site center. Along the western side of the site, there are numerous large rock overhangs and ledges several meters wide and deep, with some tilted at acute angles. Large, distinct sediment-filled depressions and channels were observed along the southern edge of the monitoring site.

  There is a distinct difference between the community on the flat top of the structure and that associated with the sloping sides and flanks. Biota observed on the top of the feature include *Bebryce cineriea/grandis*, *Ctenocella* (*Ellisella*) spp., *Nicella* spp., crinoids, *Antipathes* spp., *Stichopathes lutkeni*, coralline algae, several species of sponges; *Astrocyclus caecilia*, and *R. manuelensis*. The occurrence of R. manuelensis on the top of Site 7 may be due to the less uniform topography at this site. The species does not appear in the areas of lowest relief atop the feature. On the edges, sides, and adjacent rock structures, *R. manuelensis* is the dominant epibiota, with crinoids, *Antipathes* spp., *Stichopathes lutkeni*, coralline algae (down to approximately 76 m), *Madracis/Oculina* sp., the unidentified solitary scleractinian, and several sponges also observed. Along the exposed edges of the large rock overhangs, *Madracis/Oculina* sp. and unidentified scleractinian were abundant. In the areas of scattered shell and rubble surrounding the feature are crinoids, with small colonies of *Antipathes* spp. also in evidence.

- Site 8 is a medium-relief site with a rugged mound near its center and numerous crevices and overhangs associated with the feature. The mound is slightly elongated, approximately 40 m in north-south extent and 15 m in east-west extent, with a smaller mound located nearby to the east. The relief of the smaller mound is 7-8 m above the surrounding seafloor. The entire feature is covered by silt with areas of thicker deposits on horizontal surfaces and in depressions and crevices.

  Rhizopsammia manuelensis was evident on the entire structure from just above the base to the top, with lower densities observed on horizontal surfaces with a heavier silt accumulation. Other observed epibiota included the *Ctenocella* (*Ellisella*) spp., *Hypnogorgia pendula*, *Nicella* spp., *Thesea* spp., *Antipathes* spp., *Stichopathes lutkeni*, and *Madrepora carolina*. There is no obvious zonation of any of these taxa except for higher abundances of *Hypnogorgia pendula* occurring near the top of the feature. The arrow crabs, *Stenohynchus seticornis* and *Astrocyclus caecilia*, crinoids, and the sea urchins *Diadema antillarum* and *Stylocidaris affinis* were also observed on the mounds. The species colonizing the lower relief mounds appear similar in composition to those on the primary feature.

- Site 9 is low relief consisting of low subcircular mounds, generally 0.5-2 m in height with diameters of 5-20 m. There are a few features with up to 5-m relief with ledges, overhangs, and crevices. A few outcrops are much larger with heights up to 5 m and diameters greater than 10 m. Many of the medium to large structures are flattened and greatly undercut with wide overhangs and vertical holes down through the mounds. The bases of the features are covered with silt up to a height of about 0.5 m. Some areas of low rock are completely covered and the buried hard substrate is only apparent from the gorgonian fans and whips protruding through the silt.

  Biota on the lower relief structures includes *Bebryce cinerea/grandis, Hypnogorgia pendula*, *Nicella* spp., *Swiftia exserta*, *Thesea* spp., *Ctenocella* (*Ellisella*) spp., *Antipathes* spp., *Madrepora carolina*, and occasional crinoids. *Ctenocella* (*Ellisella*) spp. had substantially higher abundances at this site than the other surveyed sites especially on the low-relief rock outcrops. Some smaller mounds (1 m in height) had few colonies of *R. manuelensis*; however, the larger mounds had very high numbers of *R. manuelensis* on the upper 2-3 m of the structure, along with larger octocoral fans.

3.2.2.3. Topographic Features

The shelf edge, shelf, and mid-shelf of the Western and Central Gulf are characterized by topographic features that are inhabited by hard-bottom benthic communities. The habitat created by the topographic features is important for the following reasons:

(1) they support hard-bottom communities of high biomass, high diversity, and high numbers of plant and animal species;

(2) they support, either as shelter or food, or both, large numbers of commercially and recreationally important fishes;

(3) they are unique to the extent that they are small, isolated areas of such communities in vast areas of much lower diversity;

(4) they provide a relatively pristine area suitable for scientific research (especially the East and West Flower Garden Banks); and

(5) they have an aesthetically intrinsic value.

Figure 3-4 depicts the location of 39 known topographic features in the Gulf of Mexico; 23 in the WPA and 16 in the CPA.

Benthic organisms on these features are mainly limited by temperature and light (lack of); extreme water temperature and light intensity are known to stress corals. Temperatures lower than 16 °C reduce coral growth, while temperatures in excess of 32 °C will impede coral growth and induce coral bleaching (loss of symbiotic zooxanthellae). While intertidal corals are adapted to high light intensity, most corals become stressed when exposed to unusually high light levels. Furthermore, although corals will grow or survive under low light level conditions, they do best submerged in clear, nutrient-poor waters. Light penetration in the Gulf is limited by several factors including depth and events of prolonged turbidity. Hard substrates favorable to colonization by coral communities in the northern Gulf are found on outer shelf, high-relief features. These substrates are found above the nepheloid layer, are off the muddy seafloor, and are bathed most of the year in nutrient-poor waters. The East and West Flower Garden Banks are examples of such suitable substrates. From 1990 to 1995, horizontal Secchi disk water turbidity over the coral reef has been estimated at 46 m during the summer, and water temperature ranged from 19 to 30 °C at a 20-m depth (Gittings, personal communication, 1996).

The banks of the Gulf of Mexico have been identified and classified into seven distinct biotic zones (Table 3-4) (modified/updated from Rezak et al., 1983 and 1985); however, none of the banks contain all seven zones. The zones are divided into the following four categories depending upon the degree of reef-building activity in each zone.

Zones of Major Reef Building and Primary Production

Diploria-Montastraea-Porites Zone

This zone is characterized by 18-20 hermatypic coral species and is found predominantly at the East and West Flower Garden Banks. The dominant species/groups of the zone in order of dominance are the *Montastraea annularis complex* (this group includes *M. franksii*, *M. faveolata*, and *M. annularis*), *Diploria strigosa*, *Porites asteroides, Colpophyllia natans,* and *Montastraea cavernosa* (Dokken et al., in preparation). Coralline algae are abundant in areas, which adds substantial amounts of calcium carbonate to the substrate. In addition to the coralline algae, there is a considerable amount of bare reef rock, which fluctuates in percent cover with the appearance of a red-turf like algae, at both banks. Red turf algae (primarily Order Ceramiales) is the dominant algal group at the East and West Flower Garden Banks and has increased in percent cover substantially over the last several years. Dokken et al. (in preparation) reported algal percent cover at both banks was significantly greater during 1999 than 1998. Percent coral cover in this zone is estimated at 59.0 percent and 54.6 percent at the East and West Banks, respectively (Dokken et al., in preparation).

Typical sport and commercial fish observed in this zone include various grouper species, amberjack, barracuda; red, gray, and vermillion snapper; cottonwick; and porgy. There is also a diverse group of tropical reef fish species found on these banks, including creole fish; queen, stoplight, red band, and princess parrot fish; rock beauty; blue tang, and the whitespotted filefish, just to name a few. There are over 175 tropical reef species that reside within the high-diversity zone at the Flower Garden Banks (Dennis and Bright, 1988; Pattengill, 1998). This high-diversity *Diploria/Montastraea/Porites* Zone is found only at the East and West Flower Garden Banks in water depths less than 36 m.

Madracis and Fleshy Algal Zone

The *Madracis* Zone is dominated by the small branching coral *Madracis mirabilis*, which produces large amounts of carbonate sediment. In places, large (possibly ephemeral) populations of turf-like algae dominate the *Madracis* gravel substratum (Algal Zone). The *Madracis* Zone appears to have a successional relationship with the *Diploria-Montastraea-Porites* Zone. *Madracis* colony remains build up the substrate and allow the successional species to grow. The zone occurs at the East and West Flower Garden Banks on peripheral components of the main reefal structure between 28 and 46 m.

Stephanocoenia-Millepora Zone

The *Stephanocoenia-Millepora* Zone is inhabited by a low-diversity coral assemblage of 12 hermatypic corals and can be found at the Flower Garden, McGrail, and Bright Banks. The eight most conspicuous corals in order of dominance are *Stephanocoenia michelinii, Millepora alcicornis*, *Montastraea cavernosa*, *Colpophyllia natans*, *Diploria strigosa*, *Agaricia agaricites*, *Mussa angulosa*, and *Scolymia cubensis*. The assemblages associated with this zone are not well known; coralline algae is the most conspicuous organism in the zone. Additionally, reef fish populations are less diverse; but the Atlantic spiny oyster (*Spondylus americanus*) appears numerous. The depth range of this zone is between 36 and 52 m.

Algal-Sponge Zone

The Algal-Sponge Zone covers the largest area among the reef-building zones. The dominant organisms of the zone are the coralline algae, which are the most important carbonate-nodule producers. The alga nodules range from 1 to 10 cm in size, cover 50-80 percent of the bottom, and generally occur between 55 and 85 m. The habitat created by the alga nodules supports communities that are probably as diverse as the coral-reef communities. Most of the leafy algae found on the banks occur in this zone and contribute large amounts of food to the surrounding communities. Calcareous green algae (*Halimeda* and *Udotea)* and several species of hermatypic corals are major contributors to the substrate. Deepwater alcyonarians are abundant in the lower Algal-Sponge Zone. Sponges, especially *Neofibularia nolitangere,* are conspicuous. Echinoderms are abundant and also add to the carbonate substrate. Small gastropods and pelecypods are also abundant. Gastropod shells are known to form the center of some of the algal nodules. Characteristic fish of the zone are yellowtail reef fish, sand tilefish, cherubfish, and orangeback bass.

Partly drowned reefs are a major biotope of the Algal-Sponge Zone. They are defined as those reefal structures covered with living crusts of coralline algae with occasional boulders of hermatypic corals. In addition to the organisms typical to the rest of the Algal-Sponge Zone, the partly drowned reefs are also inhabited by large anemones, large comatulid crinoids, basket stars, limited crusts of *Millepora*, and infrequent small colonies of other hermatypic species. The relief and habitat provided by the carbonate structures also attract a variety of fish species, especially yellow tail reef fish and blue and queen angelfish.

Zone of Minor Reef Building

Millepora-Sponge Zone

The *Millepora*-Sponge Zone occupies depths comparable to the *Diploria-Montastraea-Porites* Zone on the claystone-siltstone substrate of the Texas-Louisiana midshelf banks. One shelf-edge carbonate bank, Geyer Bank, also exhibits the zone but only on a bedrock prominence. Crusts of the hydrozoan coral, *Millepora alcicornis*, sponges, and other epifauna occupy the tops of siltstone, claystone, or sandstone outcrops in this zone. Scleractinian corals and coralline algae are rarely observed.

Transitional Zone of Minor to Negligible Reef Building

Antipatharian Zone

This transitional zone is not distinct but blends in with the lower Algal-Sponge Zone. It is characterized by an abundance of antipatharian whips growing with the algal-sponge assemblage. With increased water depth, the assemblages of the zone become less diverse, characterized by antipatharians, comatulid crinoids, few leafy or coralline algae, and limited fish (yellowtail redfish, queen angelfish, blue angelfish, and spotfin hogfish). Again, the depth of this zone differs at the various banks but generally extends to 90 m.

Zone of No Reef Building

Nepheloid Zone

High turbidity, sedimentation, and resuspension occur in this zone. Rocks or drowned reefs are covered with a thin veneer of sediment and epifauna are scarce. The most noticeable are comatulid crinoids, octocoral whips and fans, antipatharians, encrusting sponges, and solitary ahermatypic corals. The fish fauna is different and less diverse than those of the coral reefs or partly drowned reefs. These fish species include red snapper, spanish flag, snowy grouper, bank butterflyfish, scorpionfishes, and roughtongue bass. This zone occurs on all banks, but its depth differs at each bank. Generally, the Nepheloid Zone begins at the limit of the Antipatharian Zone and extends to the surrounding soft bottom.

Banks of the Gulf of Mexico

Shelf-Edge Banks		Midshelf Banks		South Texas Banks
Western	Central	Western	Central	Western Only
East Flower Garden Bank	Bright Bank	Claypile Lump	Sonnier Bank	Big Dunn Bar
West Flower Garden Bank	McGrail Bank	32 Fathom Bank	Fishnet Bank	Small Dunn Bar
Geyer Bank	Alderdice Bank	29 Fathom Bank	29 Fathom Bank	Blackfish Ridge
Rankin Bank	Rankin Bank	Stetson Bank		Mysterious Bank
Elvers Bank	Rezak Bank	Coffee Lump		Baker Bank
MacNeil Bank	Sidner Bank			Aransas Bank
Appelbaum Bank	Ewing Bank			Southern Bank
				North Hospital Bank
				Hospital Bank
				South Baker Bank
				Dream Bank

Figures 3-5 and 3-6 illustrate the topographic relief associated with several of the more developed features, i.e., the East and West Flower Garden Banks and Stetson Bank.

Shelf-Edge Banks

The shelf-edge banks of the Western and Central Gulf generally exhibit the *Diploria-Montastraea-Porites* zonation that is exhibited at the East and West Flower Garden Banks at comparable depths. However, Geyer Bank (37-m crest), which is within the depth of the high-diversity, coral-reef zone, does not exhibit the high-diversity characteristics. Instead, Geyer Bank has a well-developed *Millepora*-Sponge Zone, which is typically the defining characteristic of midshelf banks found elsewhere in the Gulf of Mexico.

Midshelf Banks

Five midshelf banks contain the *Millepora*-Sponge Zone: Sonnier, 29 Fathom, and Fishnet Banks in the Central Gulf; and Stetson and Claypile Banks in the Western Gulf. The nepheloid layer often enfolds Claypile Bank, considered a low-relief bank with only 10 m of relief. Therefore, the level of development of the *Millepora*-Sponge community is lowest at Claypile Bank. Two other midshelf banks in the Western Gulf (32 Fathom Bank and Coffee Lump) are also low-relief banks with less than 10 m of relief.

Stetson Bank is isolated from other banks by waters over 50 m and lies near the northern physiological limit for the advanced development of reef-building, hermatypic corals. The species composition is markedly different from that of other tropical reefs including the Flower Garden Banks. However, in addition to the *Millepora*-Sponge characteristics at Stetson Bank, there are sparsely distributed reef- and nonreef-building coral species found. *Madracis decactus*, *Agaricia fragilis*, (ahermatypic corals), *Stephenocoenia michelinii*, and *Diploria strigosa* (hermatypic corals) are among the most dominant coral species found at Stetson Bank. In addition to Stetson's unique landscape and topographic features (Figure 3-6), there is a large distribution of marine life residing at the bank. Over 140 species of reef and schooling fishes, 108 mollusks, and 3 predominant echinoderms are reported. Due to its vertical orientation, Stetson attracts a number of pelagic species that move back and forth across the continental shelf utilizing various banks, including the Flower Gardens, for seasonal feeding, mating, and as nursery ground. These large pelagic animals include species such as manta and devil rays and the filter-feeding whale shark.

Figure 3-7 shows the 1-Mile and 3-Mile Zones around Sonnier Bank as examples of the protective zonation that would be established by the Topographic Features Stipulation proposed for these proposed lease sales.

South Texas Banks

The South Texas banks are geographically/geologically distinct from the shelf-edge banks. Several of the South Texas banks are also low-relief banks. These banks exhibit a reduced biota and have relatively low relief, few hard-substrate outcrops, and a thicker sediment cover than the other banks.

It has been suggested that four other South Texas features in the Western Gulf be considered as sensitive offshore topographic features: Phleger, Sebree, and Big and Small Adam Banks. Phleger Bank (a shelf-edge bank) crests at 122 m, deeper than the lower limit of the No Activity Zones (85 m [100 m in the case of the Flower Gardens]). The depth of the bank precludes the establishment of the Antipatharian Zone so that even though the bank is in clear water, the biota is typical of the nepheloid zone. The bank appears to be predominantly covered with sand, with scattered rock outcrops of approximately 1-2 m in diameter and 1 m in height. The sand substrate is devoid of sessile benthic organisms, although the rock outcrops support a number of epifaunal species such as cup-shaped and encrusting sponges, octocorals, and crinoids. Roughtongue bass were observed in video surveys to be the dominant fish species on this bank.

Sebree Bank, located in 36.5 m of water, is a low-relief feature of approximately 3 m in relief and is located in an area subject to high sedimentation. Clusters of the scleractinian coral, *Oculina diffusa*, have been observed on the rocky outcrops of this bank. This species tends to thrive in habitats exhibiting low light and high sedimentation. It forms twisted, rather low-relief colonies, and does not create reefs or distinctive assemblages of reefal species. The bank attracts abundant nektonic species, including red snapper and other commercially and recreationally important finfish (Tunnell, 1981). Findings in the August 1993 cooperative dive effort on Sebree Bank by MMS, the State of Texas, and Texas A&M University at Corpus Christi (Dokken et al., 1993) were generally consistent with those reported by Tunnell (1981).

Dokken et al. (1993) compared the nepheloid dominated, low-diversity community of Sebree Bank with the nepheloid zone community described by Rezak et al. (1985). Rezak and Bright (1981) devised an environmental priority index to rate the sensitivity of topographic features in the northern Gulf of Mexico:

A. South Texas midshelf relict Pleistocene carbonate reefs bearing turbidity tolerant Antipatharian Zone and Nepheloid Zone (surrounding depths of 60-80 m, crests 56-70 m).

B. North Texas-Louisiana midshelf, Tertiary-outcrop banks bearing clear-water, *Millepora*-Sponge Zone and turbid-water-tolerant Nepheloid Zone (surrounding depths of 50-62 m, crests 18-40 m.

C. North Texas-Louisiana midshelf banks bearing turbidity-tolerant assemblages approximating the Antipatharian Zone (surrounding depths of 65-78 m, crests 52-66 m).

D. North Texas-Louisiana shelf-edge, carbonate banks bearing clear-water coral reefs and Algal-Sponge Zones, transitional assemblages approximating the Antipatharian Zone and Nepheloid Zone (surrounding depths of 84-200 m, crests 15-75 m).

E. Eastern Louisiana shelf-edge, carbonate banks bearing poorly developed elements of the Algal-Sponge Zone, transitional Antipatharian Zone assemblages, and Nepheloid Zone (surrounding depths of 100-110 m, crests 67-73 m).

They categorized similar features containing nepheloid zone communities as Class D banks, where protection is not recommended. Since Sebree Bank is located within a shipping fairway, it is relatively well protected from physical impacts (anchoring or drilling disturbance). While they did not specifically discuss Sebree Bank, based on five ranking criteria, similar nepheloid zone communities were given the lowest rating of all the topographic features.

Big and Small Adam Banks are also low-relief features subject to sedimentation. Rezak and Bright (1981) categorized these features as Class D banks, where protection is not recommended. Although the banks may contain the Antipatharian Zone, this designation is speculative (Rezak et al., 1983). Big and Small Adam Banks were given the lowest ratings of those topographic features discussed by Rezak and Bright (1981), based on their criterion for environmental priority rankings.

3.2.3. Deepwater Benthic Communities

Chemosynthetic communities are remarkable in that they utilize a carbon source independent of photosynthesis and the sun-dependent photosynthetic food chain that supports all other life on earth. Although the process of chemosynthesis is entirely microbial, chemosynthetic bacteria and their production can support thriving assemblages of higher organisms through symbiosis. The first discovery of deep-sea chemosynthetic communities including higher animals was unexpectedly made at hydrothermal vents in the eastern Pacific Ocean during geological explorations (Corliss et al., 1979). The principal organisms included tube worms, clams, and mussels that derive their entire food supply from symbiotic chemosynthetic bacteria, which obtain their energy needs from chemical compounds in the venting fluids. Similar communities were first discovered in the Eastern Gulf of Mexico in 1983 at the bottom of the Florida Escarpment in areas of "cold" brine seepage (Paull et al., 1984). The fauna here was found to be generally similar to vent communities including tube worms, mussels, and rarely, vesicomyid clams.

Two groups fortuitously discovered chemosynthetic communities in the Central Gulf of Mexico concurrently in November 1984. During investigations by Texas A&M University to determine the effects of oil seepage on benthic ecology (until this investigation, all effects of oil seepage were assumed to be detrimental), bottom trawls unexpectedly recovered extensive collections of chemosynthetic organisms including tube worms and clams (Kennicutt et al., 1985). At the same time, LGL Ecological Research Associates was conducting a research cruise as part of the multiyear MMS Northern Gulf of Mexico Continental Slope Study (LGL Ecological Research Associates, Inc. and Texas A&M University, 1986). Bottom photography (processed on board the vessel) resulted in clear images of vesicomyid clam chemosynthetic communities. Photography during the same LGL/MMS cruise also documented tube-worm communities *in situ* in the Central Gulf of Mexico for the first time (not processed until after the cruise; Boland, 1986) prior to the initial submersible investigations and firsthand descriptions of Bush Hill in 1986 (Rosman et al., 1987a; MacDonald et al., 1989).

Distribution

There is a clear relationship between known hydrocarbon discoveries at great depth in the Gulf slope and chemosynthetic communities, hydrocarbon seepage, and authigenic minerals including carbonates at the seafloor (Sassen et al., 1993a and b). While the hydrocarbon reservoirs are broad areas several kilometers beneath the Gulf, chemosynthetic communities occur in isolated areas with thin veneers of sediment only a few meters thick.

The northern Gulf of Mexico slope includes a stratigraphic section more than 10 km thick and has been profoundly influenced by salt movement. Mesozoic source rocks from Upper Jurassic to Upper Cretaceous generate oil in most of the Gulf slope fields (Sassen et al., 1993a and b). Migration conduits supply fresh hydrocarbon materials through a vertical scale of 6-8 km toward the surface. The surface expressions of hydrocarbon migration are referred to as seeps. Geological evidence demonstrates that hydrocarbon and brine seepage persists in spatially discrete areas for thousands of years. The time scale for oil and gas migration (combination of buoyancy and pressure) from source systems is on the scale of millions of years (Sassen, 1997). Seepage from hydrocarbon sources through faults towards the surface tends to be diffused through the overlying sediment, carbonate outcroppings, and hydrate deposits so the corresponding hydrocarbon seep communities tend to be larger (a few hundred meters wide) than chemosynthetic communities found around the hydrothermal vents of the Eastern Pacific (MacDonald, 1992). There are large differences in the concentrations of hydrocarbons at seep sites.

The widespread nature of Gulf of Mexico chemosynthetic communities was first documented during contracted investigations by the Geological and Environmental Research Group (GERG) of Texas A&M University for the Offshore Operators Committee (Brooks et al., 1986). The occurrence of chemosynthetic organisms dependent on hydrocarbon seepage has been documented in water depths as shallow as 290 m (Roberts et al., 1990) and as deep as 2,200 m (MacDonald, 1992). This depth range specifically places chemosynthetic communities in the deepwater region of the Gulf of Mexico, which is defined as water depths greater than 305 m (1,000 ft). Chemosynthetic communities are not found on the continental shelf. At least 45 communities are now known to exist in 43 OCS blocks (Figure 4-1 and Table 3-8). Although a systematic survey has not been done to identify all chemosynthetic communities in the Gulf, there is evidence indicating that many more such communities may exist. The depth limits of discoveries probably reflect the limits of exploration (lack of submersibles capable of depths over 1,000 m). MacDonald et al. (1993 and 1996) have analyzed remote-sensing images from space that reveal the presence of oil slicks across the north-central Gulf of Mexico. Results confirmed extensive natural oil seepage in the Gulf, especially in water depths greater than 1,000 m. A total of 58 additional potential locations were documented where seafloor sources were capable of producing perennial oil slicks (MacDonald et al., 1996). Estimated seepage rates ranged from 4 to 70 bbl/day compared to less than 0.1 bbl/day for ship discharges (both normalized for 1,000 mi^2 (3,430 km^2)). This evidence considerably increases the area where chemosynthetic communities dependent on hydrocarbon seepage may be expected.

The densest aggregations of chemosynthetic organisms have been found at water depths of around 500 m and deeper. The best known of these communities was named Bush Hill by the investigators who first described it (MacDonald et al., 1989). It is a surprisingly large and dense community of chemosynthetic tube worms and mussels at a site of natural petroleum and gas seepage over a salt diapir in Green Canyon Block 185. The seep site is a small knoll that rises about 40 m above the surrounding seafloor in about 580-m water depth.

Stability

According to Sassen (1997) the role of hydrates at chemosynthetic communities has been greatly underestimated. The biological alteration of frozen gas hydrates was first discovered during the recent MMS study “Stability and Change in Gulf of Mexico Chemosynthetic Communities.” It is hypothesized (MacDonald, 1998) that the dynamics of hydrate alteration could play a major role as a mechanism for regulation of the release of hydrocarbon gases to fuel biogeochemical processes and could also play a substantial role in community stability. Recorded bottom-water temperature excursions of several degrees in some areas such as the Bush Hill site (4-5 °C at 500-m depth) are believed to result in dissociation of hydrates, resulting in an increase in gas fluxes (MacDonald et al., 1994). Although not as destructive as the volcanism at vent sites of the mid-ocean ridges, the dynamics of shallow hydrate formation and movement will clearly affect sessile animals that form part of the seepage barrier. There is potential of a catastrophic event where an entire layer of shallow hydrate could break free of the bottom and result in considerable impact to local communities of chemosynthetic fauna. At deeper depths (>1,000 m), the bottom-water temperature is colder (by approximately 3 °C) and undergoes less fluctuation. The formation of more stable and probably deeper hydrates influences the flux of light hydrocarbon gases to the surface, thus influencing the surface morphology and characteristics of chemosynthetic communities. Within complex communities such as Bush Hill, oil seems less important than previously thought (MacDonald, 1998).

Through taphonomic studies (death assemblages of shells) and interpretation of seep assemblage composition from cores, Powell (1995) reported that, overall, seep communities were persistent over periods of 500-1,000 years. Some sites retained optimal habitat over geological time scales. Powell reported evidence of mussel and clam communities persisting in the same sites for 500-4,000 years. Powell also found that both the composition of species and trophic tiering of hydrocarbon seep communities tend to be fairly constant across time, with temporal variations only in numerical abundance. He found few cases in which the community type changed (from mussel to clam communities, for example) or had disappeared completely. Faunal succession was not observed. Surprisingly, when recovery occurred after a past destructive event, the same chemosynthetic species reoccupied a site. There was little evidence of catastrophic burial events, but two instances were found in mussel communities in Green Canyon Block 234. The most notable observation reported by Powell (1995) was the uniqueness of each chemosynthetic community site.

Precipitation of authigenic carbonates and other geologic events will undoubtedly alter surface seepage patterns over periods of 1-2 years, although through direct observation, no changes in chemosynthetic fauna distribution or composition were observed at seven separate study sites (MacDonald et al., 1995). A slightly longer period (12 years) can be referenced in the case of Bush Hill, the first community described *in situ* in 1986. No mass die-offs or large-scale shifts in faunal composition have been observed (with the exception of collections for scientific purposes) over the 12-year history of research at this site.

Biology

MacDonald et al. (1990) has described four general community types. These are communities dominated by Vestimentiferan tube worms (*Lamellibrachia c.f. barhami* and *Escarpia* n.sp.), mytilid mussels (Seep Mytilid Ia, Ib, and III, and others), vesicomyid clams (*Vesicomya cordata* and *Calyptogena ponderosa*), and infaunal lucinid or thyasirid clams (*Lucinoma* sp. or *Thyasira* sp.). These faunal groups tend to display distinctive characteristics in terms of how they aggregate, the size of aggregations, the geological and chemical properties of the habitats in which they occur and, to some degree, the heterotrophic fauna that occur with them. Many of the species found at these cold seep communities in the Gulf are new to science and remain undescribed. As an example, at least six different species of seep mussels have been collected but none is yet described.

Individual lamellibranchid tube worms, the longer of two taxa found at seeps (the other is an *Escarpia*-like species but probably a new genus) can reach lengths of 3 m and live hundreds of years (Fisher et al., 1997). Growth rates determined from recovered marked tube worms have been variable, ranging from no growth of 13 individuals measured one year to a maximum growth of 20 mm per year in a *Lamellibrachia* individual. Average growth rate was 2.5 mm/yr for the *Escarpia*-like species and 7.1 mm/yr for lamellibrachids. These are slower growth rates than those of their hydrothermal vent relatives, but *Lamellibrachia* individuals can reach lengths 2-3 times that of the largest known hydrothermal vent species. Individuals of *Lamellibrachia* sp. in excess of 3 m have been collected on several occasions, representing probable ages in excess of 400 years (Fisher, 1995). Vestimentiferan tube worm spawning is not seasonal and recruitment is episodic.

Growth rates for methanotrophic mussels at cold seep sites have recently been reported (Fisher, 1995). General growth rates were found to be relatively high. Adult mussel growth rates were similar to mussels from a littoral environment at similar temperatures. Fisher also found that juvenile mussels at hydrocarbon seeps initially grow rapidly, but the growth rate drops markedly in adults; they grow to reproductive size very quickly. Both individuals and communities appear to be very long lived. These methane-dependent mussels have strict chemical requirements that tie them to areas of the most active seepage in the Gulf of Mexico. As a result of their rapid growth rates, mussel recolonization of a disturbed seep site could occur relatively rapidly. There is some early evidence that mussels also have some requirement of a hard substrate and could increase in numbers if suitable substrate is increased on the seafloor (Fisher, 1995).

Unlike mussel beds, chemosynthetic clam beds may persist as a visual surface phenomenon for an extended period without input of new living individuals because of low dissolution rates and low sedimentation rates. Most clam beds investigated by Powell (1995) were inactive. Living individuals were rarely encountered. Powell reported that over a 50-year timespan, local extinctions and recolonization should be gradual and exceedingly rare.

Extensive mats of free-living bacteria are also evident at hydrocarbon seep sites. These bacteria may compete with the major fauna for sulfide and methane energy sources and may also contribute substantially to overall production (MacDonald, 1998). The white, nonpigmented mats were found to be an autotrophic sulfur bacteria *Beggiatoa* species, and the orange mats possessed an unidentified nonchemosynthetic metabolism (MacDonald, 1998).

Preliminary information has been presented by Carney (1993) concerning the nonchemosynthetic animals (heterotrophs) found in the vicinity of hydrocarbon seeps. Heterotrophic species at seep sites are a mixture of species unique to seeps (particularly molluscs and crustacean invertebrates) and those that are a normal component from the surrounding environment. Carney reports a potential imbalance that could occur as a result of chronic disruption. Because of sporadic recruitment patterns, predators could gain an advantage, resulting in exterminations in local populations of mussel beds.

Detection

Chemosynthetic communities cannot be reliably detected directly using geophysical techniques; however, hydrocarbon seeps that allow chemosynthetic communities to exist modify the geological characteristics in ways that can be remotely detected. These known sediment modifications include (1) precipitation of authigenic carbonate in the form of micronodules, nodules, or rock masses; (2) formation of gas hydrates; (3) modification of sediment composition through concentration of hard chemosynthetic organism remains (such as shell fragments and layers); (4) formation of interstitial gas bubbles or hydrocarbons; and (5) formation of depressions or pockmarks by gas expulsion. These features give rise to acoustic effects such as wipeout zones (no echoes), hard bottoms (strongly reflective echoes), bright spots (reflection enhanced layers), or reverberant layers (Behrens, 1988; Roberts and Neurauter, 1990). Potential locations for most types of communities can be determined by careful interpretation of these various geophysical modifications, but to date, the process remains imperfect and confirmation of living communities requires direct visual techniques.

As part of the recent MMS study, "Stability and Change in Gulf of Mexico Chemosynthetic Communities," Sager (1997) characterized the geophysical responses of seep areas that support chemosynthetic communities so that a protocol can be refined to use geophysical remote-sensing techniques to locate chemosynthetic communities reliably. One objective is to use geophysical mapping techniques to reduce the seafloor area that may require searching by much slower and expensive near-bottom techniques. An additional study involving groundtruthing of geophysical characteristics and observed chemosynthetic communities, which is currently underway (2000-2002), will also improve predicative capabilities.

3.2.4. Marine Mammals

Twenty-nine species of marine mammals are known to occur in the Gulf of Mexico (Davis et al., 2000). The Gulf's marine mammals (Table 3-36) are represented by members of the taxonomic order Cetacea, which is divided into the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales, dolphins, and their allies), as well as the order Sirenia, which include the manatee and dugong. Within the GOM, there are 28 species of cetaceans (7 mysticete and 21 odontocete species) and 1 sirenian species, the manatee (Jefferson et al., 1992).

Prior to 1973, the California sea lion (*Zalophus californianus*) was sometimes reported in Gulf waters (Gunter, 1977). These animals were likely escapees or released from sea life parks located in the region. It appears the animals did not form stable feral colonies, since extensive aerial and shipboard surveys conducted in the Gulf during the last 10 years have not resulted in any sightings of this species. A California sea lion was photographed in November 1991 at the Marine Research Station at Holguin, Cuba (Laist, personal communication, 2001). The animal was captured two years earlier in a bay on the Caribbean coast of Cuba.

3.2.4.1. Nonendangered and Nonthreatened Species

Two of the seven species of mysticetes known to occur in the Gulf are not presently listed as endangered or threatened. With the exception of the sperm whale, none of the odontocetes known to occur in the Gulf are currently listed as endangered or threatened.

Cetaceans — Mysticetes

Bryde's Whale (Balaenoptera edeni)

The Bryde's whale (*Balaenoptera edeni*) is the second smallest of the balaenopterid whales; it is generally confined to tropical and subtropical waters (i.e., between lat. 40°N. and lat. 40°S.) (Cummings, 1985). Unlike some baleen whales, it does not have a well-defined breeding season in most areas; thus, calving may occur throughout the year. The Bryde's whale feeds on small pelagic fishes and invertebrates (Leatherwood and Reeves, 1983; Cummings, 1985; Jefferson et al., 1993).

There are more records of Bryde's whale than of any other baleen whale species in the northern Gulf of Mexico. It is likely that the Gulf represents at least a portion of the range of a dispersed, resident population of Bryde's whale (Jefferson and Schiro, 1997). Bryde's whale in the northern Gulf, with few exceptions, have been sighted along a narrow corridor near the 100-m (328-ft) isobath (Davis and Fargion, 1996; Davis et al., 2000). Most sightings have been made in the DeSoto Canyon region and off western Florida, though there have been some in the west-central portion of the northeastern Gulf. Group sizes range from one to seven animals. Abundance estimates are 29 and 25 individuals from ship and aerial surveys of the EPA slope, respectively, and 22 individuals for the oceanic northern Gulf (Davis et al., 2000). These data suggest that the northern Gulf may represent at least a portion of the range of a dispersed, resident population of Bryde's whale (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000).

Minke Whale (Balaenoptera acutorostrata)

The minke whale *(Balaenoptera acutorostrata*) is a small rorqual that is widely distributed in tropical, temperate, and polar waters. Minke whales may be found offshore but appear to prefer coastal waters. Their diet consists of invertebrates and fishes (Leatherwood and Reeves, 1983; Stewart and Leatherwood, 1985; Jefferson et al., 1993; Würsig et al., 2000).

At least three geographically isolated populations are recognized: North Pacific, North Atlantic, and Southern Hemisphere. The North Atlantic population migrates southward during winter months to the Florida Keys and the Caribbean Sea. There are 10 reliable records of minke whales in the Gulf of Mexico and all are the result of strandings (Jefferson and Schiro, 1997). Most records from the Gulf have come from the Florida Keys, although strandings in western and northern Florida, Louisiana, and Texas have been reported (Jefferson and Schiro, 1997). Sightings data suggest that minke whales either migrate into Gulf waters in small numbers during the winter or, more likely, that sighted individuals represent strays from low-latitude breeding grounds in the western North Atlantic (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000).

Cetaceans — Odontocetes

Pygmy and Dwarf Sperm Whales (Family Kogiidae)

The pygmy sperm whale *(Kogia brevicep*s) and its congener, the dwarf sperm whale *(K. sima*), are medium-sized toothed whales that feed on cephalopods and, less often, on deep-sea fishes and shrimps (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Caldwell and Caldwell, 1989). Hence, they inhabit oceanic waters in tropical to warm temperate zones (Jefferson and Schiro, 1997). They appear to be most common in waters over the continental slope and along the shelf edge. Little is known of their natural history, although a recent study of *Kogia* in South Africa has determined that these two species attain sexual maturity much earlier and live fewer years than other similarly sized toothed whales (Plön and Bernard, 1999).

Kogia have been sighted throughout the Gulf in waters that vary broadly in depth and seafloor topographies (Mullin et al., 1991; Davis et al., 1998a and 2000). The GulfCet I study reported these animals in waters with a mean bottom depth of 929 m (Davis et al., 1998a). *Kogia* have been sighted over the continental shelf, but there is insufficient evidence that they regularly inhabit continental shelf waters. *Kogia* sightings were made during GulfCet aerial surveys (1992-1997) in all waters between the 100-m and 2,000-m isobaths. Data also indicate that *Kogia* may associate with frontal regions along the shelf break and upper continental slope, areas with high epipelagic zooplankton biomass (Baumgartner, 1995). During the GulfCet II study, *Kogia* were widely distributed in the oceanic northern Gulf, including slope waters of the eastern Gulf. *Kogia* frequently strand on the coastline of the northern Gulf, more often in the eastern Gulf (Jefferson and Schiro, 1997). Between 1984 and 1990, 22 pygmy sperm whales and 10 dwarf sperm whales stranded in the Gulf of Mexico.

Because dwarf and pygmy sperm whales are difficult to distinguish from one another, sightings of either species are often categorized as *Kogia* sp. The difficulty in sighting pygmy and dwarf sperm whales is exacerbated by their avoidance reaction towards ships and their change in behavior towards approaching survey aircraft (Würsig et al., 1998). Therefore, combined estimated abundance are 66 and 188 individuals from ship and aerial surveys of the slope of the eastern Gulf, respectively, and 733 individuals for the oceanic northern Gulf (Davis et al., 2000).

Beaked Whales (Family Ziphiidae)

Two genera and four species of beaked whales occur in the GOM. These encompass (1) three species of the genus *Mesoplodon* (Sowerby's beaked whale [*M. biden*s], Blainville's beaked whale [*M. densirostri*s], and Gervais' beaked whale [*M. europaeu*s]) and (2) one species of the genus *Ziphiu*s; Cuvier's beaked whale *(Ziphius cavirostri*s). Morphological similarities among species in the genus *Mesoplodon* make identification of free-ranging animals difficult. Generally, beaked whales appear to prefer oceanic waters, although little is known of their respective life histories. Stomach content analyses suggest that these whales feed primarily on deepwater cephalopods, although they also consume some mesopelagic fishes and deepwater benthic invertebrates (Leatherwood and Reeves, 1983; Heyning, 1989; Mead, 1989; Jefferson et al., 1993).

In the northern Gulf, beaked whales are broadly distributed in waters greater than 1,000 m over lower slope and abyssal landscapes (Davis et al., 1998a and 2000). Group sizes of beaked whales observed in the northern Gulf comprise 1-4 individuals per group (Mullin et al., 1991; Davis and Fargion, 1996; Davis et al., 2000). Abundance estimates of mesoplodonts (Gervais', Blainville's, and Sowerby's beaked whales) are 0 and 59 individuals from ship and aerial surveys over the slope of the eastern Gulf, respectively, and 150 individuals for the oceanic northern Gulf (Davis et al., 2000). However, these estimates may include an unknown number of Cuvier's beaked whales. The species-specific abundance of Gervais', Blainville's, or Sowerby's beaked whale was not estimated due to the difficulty of identifying these species at sea. Abundance estimates for Cuvier's beaked whales are 0 and 22 individuals from ship and aerial surveys of the slope of the eastern Gulf, respectively, and 159 individuals for the oceanic northern Gulf (Davis et al., 2000).

Sightings data indicate that Cuvier's beaked whale is probably the most common beaked whale in the Gulf (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000). Würsig et al. (2000) indicates that there are 18 documented strandings of Cuvier's beaked whales in the Gulf. The Gervais' beaked whale is probably the most common mesoplodont in the northern Gulf, as suggested by stranding records (Jefferson and Schiro, 1997). Würsig et al. (2000) states that there are four verified stranding records of Blainville's beaked whales from the Gulf. Additionally, one beaked whale sighted during GulfCet II was determined to be a Blainville's beaked whale (Davis et al., 2000). Sowerby's beaked whale is represented in the Gulf by only a single record, a stranding in Florida; this record is considered extralimital since this species normally occurs much farther north in the North Atlantic (Jefferson and Schiro, 1997).

Dolphins (Family Delphinidae)

All remaining species of nonendangered and nonthreatened cetaceans found in the Gulf are members of the taxonomically diverse family Delphinidae. Most delphinids, with exceptions of the bottlenose dolphin and the Atlantic spotted dolphin, inhabit oceanic waters of the Gulf.

Atlantic Spotted Dolphin (Stenella frontalis)

The Atlantic spotted dolphin (*Stenella frontalis*) is endemic to the Atlantic Ocean within tropical to temperate zones. Surveys in the northern Gulf documented the Atlantic spotted dolphin primarily over the continental shelf and shelf edge in waters that were less than 250 m in depth, although some individuals were sighted along the slope in waters of up to approximately 1,000 m (3,280 ft) (Würsig et al., 2000). Mills and Rademacher (1996) found the principal depth range of the Atlantic spotted dolphin to be much shallower at 15-100 m water depth. Griffin and Griffin (1999) found Atlantic spotted dolphins on the eastern Gulf continental shelf in waters greater than 20 m (30 km from the coast). A satellite-tagged Atlantic spotted dolphin was found to prefer shallow water habitat and make short dives (Davis et al., 1996). Atlantic spotted dolphins are sighted more frequently in areas east of the Mississippi River (Mills and Rademacher, 1996). Perrin et al. (1994a) relate accounts of brief aggregations of smaller groups of Atlantic spotted dolphins (forming a larger group) off the coast of northern Florida. While not well substantiated, these dolphins may demonstrate seasonal nearshore-offshore movements that appear to be influenced by prey availability and water temperature (Würsig et al., 2000). Abundance estimates are 1,827 and 1,096 individuals from ship and aerial surveys, respectively, of the shelf of the eastern Gulf (Davis et al., 2000). Abundance estimates are 1,055 and 1,800 individuals from ship and aerial surveys, respectively, of the slope of the eastern Gulf, and 528 individuals for the oceanic northern Gulf (Davis et al., 2000). They are known to feed on a wide variety of fishes, cephalopods, and benthic invertebrates (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Perrin et al., 1994a). This species has been seen feeding in a coordinated manner on clupeid fishes in the northern Gulf, and in one instance, offshore the Florida Panhandle (Fertl and Würsig, 1995).

Bottlenose Dolphin (Tursiops truncatus)

The bottlenose dolphin *(Tursiops truncatu*s) is a common inhabitant of the continental shelf and upper slope waters of the northern Gulf. It is the most widespread and common cetacean observed in the northern Gulf. Sightings of this species in the northern Gulf are rare beyond approximately the 1,200-m (3,937-ft) isobath (Mullin et al., 1994a; Jefferson and Schiro, 1997; Davis et al., 2000). There appears to be two ecotypes of bottlenose dolphins, a coastal form and an offshore form (Hersh and Duffield, 1990; Mead and Potter, 1990). The coastal or inshore stock(s) is genetically isolated from the offshore stock (Curry and Smith, 1997). Genetic data also support the concept of relatively discrete bay, sound, and estuary stocks (Waring et al., 1999). In the northern Gulf of Mexico, bottlenose dolphins appear to have an almost bimodal distribution: a shallow water (16-67 m) and a shelf break (about 250 m) region. These regions may represent the individual depth preferences of the coastal and offshore forms (Baumgartner, 1995). Little is known of the behavior or ranging patterns of offshore bottlenose dolphins. Recently, two bottlenose dolphins that had stranded in Florida were fitted with satellite transmitters; these animals exhibited much more mobility than has been previously documented for this species (Wells et al., 1999a). One dolphin was stranded in northwestern Florida and was released in the Gulf of Mexico off central-west Florida. This dolphin moved around Florida northward to off Cape Hatteras, North Carolina, linking two regions previously considered inhabited by different continental shelf stocks. The second dolphin stranded off the Atlantic coast of Florida and moved into waters more than 5,000 m deep, much deeper than the previously held concept of bottlenose dolphin movements. This dolphin also traveled well outside of U.S. waters, which suggests the need for a different management approach than for dolphin remaining within U.S. waters. These records demonstrate the range previously reported for the offshore stock of bottlenose dolphins inhabiting the waters off the southeastern United States is larger than previously thought, and underscore the difficulties of defining pelagic stocks. Abundance estimates are 1,056 and 1,824 individuals from ship and aerial surveys, respectively, of the shelf in the eastern Gulf (Davis et al., 2000). Abundance estimates are 1,025 and 3,959 individuals from ship and aerial surveys, respectively, of the slope of the eastern Gulf, and 3,040 individuals for the oceanic northern Gulf. Abundance estimates for various Gulf bays, sounds, and estuaries are found listed in Waring et al. (1999). Best estimates by Würsig et al. (2000) for bottlenose dolphins in the northern Gulf of Mexico is 78,000. Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimp (Davis and Fargion, 1996; Jefferson and Schiro, 1997; Wells and Scott, 1999). Mating and calving occurs primarily from February through May.

Clymene Dolphin (Stenella clymene)

The Clymene dolphin *(Stenella clymen*e) is endemic to the Atlantic Ocean and found only in tropical and subtropical waters (Perrin and Mead, 1994). Data suggest that Clymene dolphins are widespread within deeper Gulf waters (i.e., shelf edge and slope) (Davis et al., 2000; Würsig et al., 2000). The Clymene dolphin represents a significant component of the northern Gulf of Mexico cetacean assemblage (Mullin et al., 1994b). However, the few records of the Clymene dolphin in the northern Gulf in the past were probably a result of this species' recently clarified taxonomic status and the tendency for observers to confuse it with other species (Jefferson and Schiro, 1997). Sightings made during GulfCet surveys indicate the Clymene dolphin to be widely distributed in the western oceanic Gulf during spring and in the northeastern Gulf during summer and winter. Also, most sightings tended to occur in the central portion of the study area, west of the Mississippi Delta and east of Galveston Bay. Clymene dolphins have been sighted in water depths of 612-1,979 m (Davis et al., 1998a). The Clymene dolphin was shown to have a relationship with the depth of the 15°C isotherm, demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995). Abundance estimates are 0 and 2,292 from ship and aerial surveys, respectively, of the continental slope of the eastern Gulf and 10,093 for the oceanic northern Gulf (Davis et al., 2000). This species appears to feed on fishes and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Mullin et al., 1994c), although knowledge of feeding habits is limited to stomach contents (small fish and squid) of two individuals (Perrin et al., 1981). The Clymene dolphin was observed employing a coordinated feeding strategy on schooling fish in the northern Gulf (Fertl et al., 1997).

False Killer Whale (Pseudorca crassidens)

The false killer whale (*Pseudorca crassidens*) occurs in oceanic waters of tropical and warm temperate zones (Odell and McClune, 1999). Most sightings have been made in waters exceeding 200 m, although there have been sightings from over the continental shelf (Davis and Fargion, 1996). Although sample sizes are small, most false killer whale sightings have been east of the Mississippi River (Mullin and Hansen, 1999). Abundance estimates are 311 and 150 individuals from ship and aerial surveys, respectively, of the slope of the eastern Gulf and 817 individuals for the oceanic northern Gulf (Davis et al., 2000). False killer whales primarily eat fish and cephalopods, but they have been known to attack other toothed whales (Leatherwood and Reeves, 1983; Jefferson et al., 1993).

Fraser's Dolphin (Lagenodelphis hosei)

The Fraser's dolphin (*Lagenodelphis hosei*) has a pantropical distribution (Perrin et al., 1994b) in oceanic waters and in areas where deep water approaches the coast. Fraser's dolphins feed on fishes, cephalopods, and crustaceans (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Jefferson and Schiro, 1997). This species was previously known to occur in the northern Gulf of Mexico based on a mass stranding in the Florida Keys in 1981 (Hersh and Odell, 1986). From 1992 to 1996, there were at least three strandings in Florida and Texas (Würsig et al., 2000). GulfCet ship-based surveys led to sightings of two large herds (greater than 100 individuals) and first-time recordings of sounds produced by these animals (Leatherwood et al., 1993). Fraser's dolphins have been sighted in the western and eastern Gulf at depths of around 1,000 m (3,281 ft) (Leatherwood et al., 1993; Davis and Fargion, 1996; Jefferson and Schiro, 1997; Davis et al., 2000).

Killer Whale (Orcinus orca)

The killer whale (*Orcinus orca*) is a cosmopolitan species that occurs in all oceans and seas (Dahlheim and Heyning, 1999). Generally, they appear to inhabit coastal, cold temperate and subpolar zones. Most killer whale sightings in the northern Gulf have been in waters greater than 200 m deep, although there are sightings made from over the continental shelf (Davis and Fargion, 1996). Killer whales are found almost exclusively in a broad area of the north-central Gulf (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997; Mullin and Hansen, 1999). There was a sighting in May 1998 of killer whales in DeSoto Canyon (Ortega, personal communication, 1998). Abundance estimates were 0 for both ship and aerial surveys for the slope of the eastern Gulf and 68 individuals for the oceanic northern Gulf (Davis et al., 2000). Thirty-two individual killer whales have been photo-identified in the Gulf; some individuals have a wide temporal and spatial distribution (some with a linear distance between sightings of more than 1,100 km) (O'Sullivan and Mullin, 1997). It is not known whether killer whales in the northern Gulf remain within the Gulf or range more widely (Würsig et al., 2000). Worldwide, killer whales feed on marine mammals, marine birds, sea turtles, cartilaginous and bony fishes, and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993). An attack by killer whales on a group of pantropical spotted dolphins was observed during one of the GulfCet surveys (O'Sullivan and Mullin, 1997).

Melon-headed Whale (Peponocephala electra)

The melon-headed whale *(Peponocephala electra*) is a deepwater, pantropical species (Perryman et al., 1994) that feeds on cephalopods and fishes (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Mullin et al., 1994a; Jefferson and Schiro, 1997). Sightings of this species in the northern Gulf have been primarily in continental slope waters west of the Mississippi River (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000; Mullin and Hansen, 1999). The first two records of this species occurrence in the Gulf are recent strandings, one in Texas in 1990, and the other in Louisiana in 1991 (Barron and Jefferson, 1993). GulfCet surveys resulted in many sightings of melon-headed whales, suggesting that this species is a regular inhabitant of the Gulf of Mexico (e.g., Mullin et al., 1994a). The abundance for the oceanic northern Gulf is estimated to be 1,734 individuals (Davis et al., 2000).

Pantropical Spotted Dolphin (Stenella attenuata)

The pantropical spotted dolphin *(Stenella attenuat*a) is distributed in tropical and subtropical marine waters of the world (Perrin and Hohn, 1994). It is the most common cetacean in the oceanic northern Gulf (Mullin et al., 1994c; Davis and Fargion, 1996; Davis et al., 2000). Pantropical spotted dolphins are typically found in waters deeper than 1,200 m deep (Mullin et al., 1994c; Davis et al., 1998a and 2000) but have been sighted over the continental shelf (Mullin et al., 1994c). Baumgartner (1995) did not find that pantropical spotted dolphins had a preference for any one habitat type; he suggested that this species might use prey species in each distinct habitat (e.g., within the Loop Current, inside a cold-core eddy, or along the continental slope). This ability may contribute to this species' success and abundance in the northern Gulf. Abundance estimates are 7,432 and 13,649 individuals from ship and aerial surveys, respectively, of the slope of the eastern Gulf and 46,625 individuals for the oceanic northern Gulf (Davis et al., 2000). It feeds on epipelagic fishes and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993).

Pygmy Killer Whale (Feresa attenuata)

The pygmy killer whale (*Feresa attenuata*) occurs in tropical and subtropical waters throughout the world (Ross and Leatherwood, 1994), although little is known of its biology or ecology. Its diet includes cephalopods and fishes, though reports of attacks on other dolphins have been reported (Leatherwood and Reeves, 1983; Jefferson et al., 1993). The pygmy killer whale does not appear to be common in the Gulf; most records are of strandings (Jefferson and Schiro, 1997). Fourteen strandings have been documented from southern Florida to south Texas. Four ship sightings occurred during the GulfCet surveys, once off the south Texas coast in November and three in the spring in the west-central portion of the GulfCet study area. Sightings of this species have been at depths of 500-1,000 m (1,641-3,281 ft) (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000). Abundance estimates are 0 and 218 individuals from ship and aerial surveys, respectively, of the slope of the eastern Gulf and 175 individuals for the oceanic northern Gulf (Davis et al., 2000).

Risso's Dolphin (Grampus griseus)

The Risso's dolphin (*Grampus griseus*) is a pantropical species that inhabits deep oceanic and continental slope waters of tropical and warm temperate zones (Kruse et al., 1999). Risso's dolphins in the northern Gulf have been frequently sighted along the shelf edge, along the upper slope, and most commonly, over or near the 200-m water isobath just south of the Mississippi River in recent years (Würsig et al., 2000). A strong correlation between Risso's dolphin distribution and the steeper portions of the upper continental slope is most likely the result of cephalopod distribution along the continental slope (Baumgartner, 1997; Davis et al., 2000). Risso's dolphins have been sighted over the continental shelf at water depths less than 200 m (Mullin et al., 1994c; Davis et al., 1998a). Strandings and GulfCet sightings have occurred in all seasons in the Gulf of Mexico, and it is likely that Risso's dolphins occur year round in the Gulf. Abundance estimates are 679 and 1,317 individuals from ship and aerial surveys, respectively, of the slope of the eastern Gulf and 3,040 individuals for the oceanic northern Gulf (Davis et al., 2000). Risso's dolphins feed primarily on squid and secondarily on fishes and crustaceans (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Baumgartner, 1997; Würsig et al., 2000).

Rough-toothed Dolphin (Steno bredanensis)

The rough-toothed dolphin (*Steno bredanensis*) occurs in tropical to warm temperate marine waters globally (Miyazaki and Perrin, 1994). Sightings in the northern Gulf occur primarily over the deeper waters (950-1,100 m) off the continental shelf (Mullin et al., 1994c; Davis et al., 1998a). Most sightings of the rough-toothed dolphin have been west of the Mississippi River (Mullin and Hansen, 1999); however, a mass stranding of 62 rough-toothed dolphins occurred near Cape San Blas, Florida, on December 14, 1997. Four of the stranded dolphins were rehabilitated and released; three carried satellite-linked transmitters (Wells et al., 1999b). Water depth at tracking locations of these individuals averaged 195 m. Data from the tracked individuals, in addition to sightings at Santa Rosa Beach on December 28-29, 1998 (Rhinehart et al., 1999), suggest a regular occurrence of this species in the northern Gulf. Abundance estimates are 16 and 165 individuals from ship and aerial surveys, respectively, of the slope of the eastern Gulf and 453 individuals for the oceanic northern Gulf (Davis et al., 2000). This species feeds on cephalopods and fishes (Leatherwood and Reeves, 1983; Jefferson et al., 1993).

Short-finned Pilot Whale (Globicephala macrorhynchus)

The short-finned pilot whale (*Globicephala macrorhynchus*) is found in warm temperate to tropical marine waters of the world, generally in deep offshore areas (Bernard and Reilly, 1999). Based on historical records (mostly strandings), the short-finned pilot whale would be considered one of the most common offshore cetaceans in the northern Gulf (Jefferson and Schiro, 1997). However, the short-finned pilot whale has only occasionally been sighted during recent surveys in the northern Gulf. One potential explanation for the preponderance of pilot whales in the older records were misidentifications of other "blackfish" (e.g., false killer, killer, pygmy killer, and melon-headed whales)(Jefferson and Schiro, 1997). In the northern Gulf, it is most commonly sighted along the continental slope at depths of 250-2,000 m (Jefferson and Schiro, 1997; Davis et al., 1998a and 2000). Short-finned pilot whales have been sighted almost exclusively west of the Mississippi River (Mullin and Hansen, 1999). There was one sighting of short-finned pilot whales in the slope in the eastern Gulf during GulfCet II, in the extreme western part of the study area (Davis et al., 2000). Stranding records have declined dramatically over the past decade, which contributes to the evidence (though not conclusively) that this population may be declining in the Gulf. Abundance estimates are 0 and 160 individuals from ship and aerial surveys, respectively, of the slope of the eastern Gulf and 1,471 individuals for the oceanic northern Gulf (Davis et al., 2000). Squid are the predominant prey, with fishes being consumed occasionally.

Spinner Dolphin (Stenella longirostris)

The spinner dolphin *(Stenella longirostris*) occurs worldwide in tropical oceanic waters (Perrin and Gilpatrick, 1994; Jefferson and Schiro, 1997). In the northern Gulf, most sightings of spinner dolphins have been east of the Mississippi River at depths of 500-1,800 m (1,641-5,906 ft) (Jefferson and Schiro, 1997; Mullin and Hansen, 1999; Davis et al., 2000). The distribution of spinner dolphins was shown to be related with the depth of the 15°C isotherm, thereby demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995). Spinner dolphins have mass stranded on two occasions in the Gulf, each time on the Florida coast. Abundance estimates were 5,319 and 8,670 individuals from ship and aerial surveys, respectively, over the slope in the eastern Gulf and 11,251 individuals in the oceanic northern Gulf (Davis et al., 2000). Spinner dolphins appear to feed on fishes and cephalopods (Würsig et al., 2000).

Striped Dolphin (Stenella coeruleoalba)

The striped dolphin *(Stenella coeruleoalba*) occurs in tropical and subtropical oceanic waters (Perrin et al., 1994c). Sightings in the northern Gulf occur primarily over the deeper waters beyond the continental shelf (Jefferson and Schiro, 1997; Davis et al., 2000; Würsig et al., 2000). The striped dolphin appears to prefer waters where the 15°C isotherm shoals (most probably relating to productivity) (Baumgartner, 1995). Abundance estimates are 416 and 2,198 individuals from ship and aerial surveys, respectively, over the slope of the eastern Gulf and 4,381 individuals for the oceanic northern Gulf (Davis et al., 2000). Striped dolphins feed primarily on small mid-water squid and fishes (especially lanternfish).

3.2.4.2. Endangered and Threatened Species

Five mysticete (or baleen) whales (the northern right, blue, fin, sei, and humpback), one odontocete (or toothed) whale (the sperm whale), and one sirenian (the West Indian manatee) occur in the Gulf of Mexico and are listed as endangered. The sperm whale is common in oceanic waters of the northern Gulf and is a resident species, while the baleen whales are considered rare or extralimital (Würsig et al., 2000). The West Indian manatee *(Trichechus manatu*s) inhabits only coastal marine, brackish, and freshwater areas.

Cetaceans — Mysticetes

Blue Whale (Balaenoptera musculus)

The blue whale (*Balaenoptera musculus*) is the largest animal known. It feeds almost exclusively on concentrations of zooplankton (Yochem and Leatherwood, 1985; Jefferson et al., 1993). The blue whale occurs in all major oceans of the world; some blue whales are resident, some are migratory (Jefferson et al., 1993; USDOC, NMFS, 1998). Those that migrate move to feeding grounds in polar waters during spring and summer, after wintering in subtropical and tropical waters (Yochem and Leatherwood, 1985). Records of the blue whale in the northern Gulf consist of two strandings on the Texas coast (Lowery, 1974). There appears to be little justification for considering the blue whale to be a regular inhabitant of the Gulf of Mexico (Jefferson and Schiro, 1997).

Fin Whale (Balaenoptera physalus)

The fin whale (*Balaenoptera physalus*) is an oceanic species that occurs worldwide in marine waters and is most commonly sighted where deep water approaches the coast (Jefferson et al., 1993). Fin whales feed on concentrations of zooplankton, fishes, and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993). The fin whale makes seasonal migrations between temperate waters, where it mates and calves, and polar feeding grounds that are occupied during summer months. Their presence in the northern Gulf is considered rare (Würsig et al., 2000). Sightings in the northern Gulf have typically been made in oceanic waters, chiefly in the north-central region of the Gulf (Mullin et al., 1991). There are seven reliable reports of fin whales in the northern Gulf, indicating that fin whales are not abundant in the Gulf of Mexico (Jefferson and Schiro, 1997). Sparse sighting data on this species suggest that individuals in the northern Gulf may be extralimital strays from their western Atlantic population (Jefferson and Schiro, 1997; Würsig et al., 2000).

Humpback Whale (Megaptera novaeangliae)

The humpback whale (*Megaptera novaeangliae*) occurs in all oceans, feeding in higher latitudes during spring, summer, and autumn, and migrating to a winter range over shallow tropical banks, where they calve and presumably conceive (Jefferson et al., 1993). Humpback whales feed on concentrations of zooplankton and fishes using a variety of techniques that concentrate prey for easier feeding (Winn and Reichley, 1985; Jefferson et al., 1993). There have been occasional reports of humpback whales in the northern Gulf off Florida: a confirmed sighting of a humpback whale in 1980 in the coastal waters off Pensacola (Weller et al., 1996); two questionable records of humpback whale sightings from 1952 and 1957 off the coast of Alabama (Weller et al., 1996); a stranding east of Destin, Florida, in mid-April 1998 (Mullin, personal communication, 1998); and a confirmed sighting of six humpback whales in May 1998 in DeSoto Canyon (Ortega, personal communication, 1998). Most recently, a lone humpback whale was photographed at Main Pass 281 in December 2001. Humpback whales sighted in the Gulf of Mexico may be extralimital strays during their breeding season or during their migrations (Würsig et al., 2000). The time of the year (winter and spring) and the small size of the animals involved in many sightings suggest the likelihood that these records are of inexperienced yearlings on their first return migration northward (Weller et al., 1996).

Northern Right Whale (Eubalaena glacialis)

The northern right whale (*Eubalaena glacialis*) inhabits primarily temperate and subpolar waters. Northern right whales range from wintering and calving grounds in coastal waters of the southeastern United States to summer feeding, nursery, and mating grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf. Five major congregation areas have been identified for the western North Atlantic right whale (southeastern United States coastal waters, Great South Channel, Cape Cod Bay, Bay of Fundy, and Scotian Shelf). The distribution of approximately 85 percent of the winter population and 33 percent of the summer population is unknown. During the winter, a portion of the population moves from the summer foraging grounds to the calving/breeding grounds off Florida, Georgia, and South Carolina. Right whales forage primarily on subsurface concentrations of zooplankton such as calanoid copepods by skim feeding with their mouths agape (Watkins and Schevill, 1976; Leatherwood and Reeves, 1983; Jefferson et al., 1993).

The northern right whale is one of the world's most endangered whales. The coastal nature and slow swimming speed of the northern right whale makes it especially vulnerable to human activities (USDOC, NMFS, 1991a). Based on a census of individual whales identified using photo-identification techniques, the western North Atlantic population size was estimated to be 295 individuals in 1992 (Waring et al., 1999). Confirmed historical records of northern right whales in the Gulf of Mexico consist of a single stranding in Texas (Schmidly et al., 1972) and a sighting off Sarasota County, Florida (Moore and Clark, 1963; Schmidly, 1981). The northern right whale is not considered a resident (year-round or seasonal) of the Gulf of Mexico; existing records probably represent extralimital strays from the wintering grounds of this species off the southeastern United States from Georgia to northeastern Florida (Jefferson and Schiro, 1997).

Sei Whale (Balaenoptera borealis)

The sei whale (*Balaenoptera borealis*) is an oceanic species that is not often seen close to shore (Jefferson et al., 1993). They occur in marine waters from the tropics to polar regions, but are more common in mid-latitude temperate zones (Jefferson et al., 1993). Sei whales feed on concentrations of zooplankton, small fishes, and cephalopods (Gambell, 1985; Jefferson et al., 1993). The sei whale is represented in the northern Gulf by only four reliable records (Jefferson and Schiro, 1997). One stranding was reported for the Florida Panhandle and three strandings were in eastern Louisiana (Jefferson and Schiro, 1997). This species' occurrence in the northern Gulf is considered most likely to be accidental.

Cetaceans — Odontocetes

Sperm Whale (Physeter macrocephalus)

The sperm whale (*Physeter macrocephalus*) inhabits marine waters from the tropics to the pack-ice edges of both hemispheres, although generally only large males venture to the extreme northern and southern portions of their range (Jefferson et al., 1993). In general, sperm whales seem to prefer certain areas within each major ocean basin, which historically have been termed "grounds" (Rice, 1989). As deep divers, sperm whales generally inhabit oceanic waters, but they do come close to shore where submarine canyons or other geophysical features bring deep water near the coast (Jefferson et al., 1993). Sperm whales prey on cephalopods, demersal fishes, and benthic invertebrates (Rice, 1989; Jefferson et al., 1993).

The sperm whale is the only great whale that is considered to be common in the northern Gulf (Fritts et al., 1983; Mullin et al., 1991; Davis and Fargion, 1996; Jefferson and Schiro, 1997). Sighting data suggest a northern Gulfwide distribution over slope waters. Congregations of sperm whales are commonly found in waters over the shelf edge in the vicinity of the Mississippi River delta in waters that are 500-2,000 m (1,641-6,562 ft) in depth (Mullin et al., 1994c; Davis and Fargion, 1996; Davis et al., 2000). Sperm whale sightings in the northern Gulf chiefly occur in waters with a mean seafloor depth of 1,105 m (Davis et al., 1998a). Mesoscale biological and physical patterns in the environment are important in regulating sperm whale habitat use (Griffin, 1999). Baumgartner (1995) noted that sperm whales avoided warm features characterized by a depressed 15°C isotherm and warm water at 100 m water depth; the highest sighting rates occurred in a cooler watermass characterized by intermediate to cool temperatures at 100 m and a moderately shallow 15°C isotherm. Sperm whales were found in waters with the steepest sea surface temperature gradient; sperm whales may forage along thermal fronts associated with eddies (Davis et al., 1998a). The GulfCet II study found that most sperm whales were concentrated along the slope in or near cyclones (Davis et al., 2000). Low-salinity, nutrient-rich water from the Mississippi River may contribute to enhanced primary and secondary productivity in the north-central Gulf, and thus provide resources that support the year-round presence of sperm whales south of the delta.

Consistent sightings in the region indicate that there is a resident population of sperm whales in the northern Gulf consisting of adult females, calves, and immature individuals (Mullin et al., 1994a; Davis and Fargion, 1996; Sparks et al., 1996; Jefferson and Schiro, 1997; Davis et al., 2000). Also, recent sightings were made in 2000 and 2001 of solitary mature male sperm whales in the DeSoto Canyon area (Lang, personal communication, 2001). Minimum population estimates of sperm whales in the entire Gulf totaled 411 individuals, as cited in the NMFS stock assessment report for 1996 (Waring et al., 1997). Subsequent abundance estimates of sperm whales in the "oceanic northern GOM" survey area totaled 387 individuals (Davis et al., 2000). Sperm whales in the Gulf are currently considered a separate stock from those in the Atlantic and Caribbean (Waring et al., 1997).

Distributions of Cetaceans within Offshore Waters of the Northern Gulf of Mexico

Factors influencing the spatial and temporal distribution and abundance of cetaceans may be environmental, biotic, or anthropogenic. Environmental factors encompass physiochemical, climatological, or geomorphological parameters. Biotic factors include the distribution and abundance of prey, inter- and intra-specific competition, reproduction, natural mortality, catastrophic events (e.g., die offs), and predation (Davis et al., 1998a). Anthropogenic factors include historical hunting pressure (on some populations or species), pollution, habitat loss and degradation, vessel traffic, recreational and commercial fishing, oil and gas development and production, seismic exploration and other manmade sources of noise in the sea.

Within the northern Gulf, many of the aforementioned environmental and biotic factors are strongly influenced by various hydrological circulation patterns. River discharge, wind stress, and the Loop Current generally drive these patterns. The major river system in this area is the Mississippi-Atchafalaya. Most of the river discharge into the northern Gulf is transported west and along the coast. Circulation on the continental shelf is largely wind-driven, with localized effects from fresh water (i.e., riverine) discharge. Beyond the shelf, the Loop Current in the eastern Gulf chiefly drives mesoscale circulation. Meanders of the Loop Current create warm-core anticyclonic eddies (anticyclones) once or twice annually that migrate westward. The anticyclones in turn spawn cold-core cyclonic eddies (cyclones). Together, anticyclones and cyclones govern the circulation of the continental slope in the central and western Gulf. The Loop Current and anticyclones are dynamic features that transport large quantities of high-salinity, nutrient-poor water across the near-surface waters of the northern Gulf. Cyclones, in contrast, contain high concentrations of nutrients and stimulate localized production. The combination of added nutrients into the northern Gulf from river outflow and mesoscale circulation features enhances productivity, and consequently the abundance of various species of fishes and cephalopods that cetaceans prey upon in the northern Gulf. The dynamics of these oceanographic features in turn affect the spatial and temporal distribution of prey species and ultimately influence cetacean diversity, abundance, and distribution (Mullin et al., 1994a; Davis et al., 2000).

Studies conducted during the GulfCet I program demonstrated a correlation of cetacean distribution patterns with certain geomorphic features such as seafloor depth or topographic relief. These studies suggested that seafloor depth was the most important variable in habitat partitioning among cetacean species in the northern Gulf (Baumgartner, 1995; Davis et al., 1998a). For example, GulfCet I surveys, along with other surveys (such as the subsequent GulfCet II program) and opportunistic sightings of cetaceans within the U.S. Gulf of Mexico, found that only the Atlantic spotted dolphin and the coastal form of the bottlenose dolphin were common inhabitants of the continental shelf. The remaining species of cetaceans known to regularly occur in the Gulf (with possible exception of the Bryde's whale) were sighted on the continental slope (Mullin et al., 1994a; Jefferson, 1995; Davis et al., 1998a and 2000). During the GulfCet II program, the most commonly sighted cetaceans on the continental slope were bottlenose dolphins (pelagic form), pantropical spotted dolphins, Risso's dolphins, and dwarf/pygmy sperm whales. The most abundant species on the slope were pantropical spotted and spinner dolphins.

Sperm whales sighted during GulfCet II surveys were found almost entirely in the north-central and northeastern Gulf, and near the 1,000-m (3,281-ft) isobath on the continental slope (Davis et al., 2000).

An objective of the GulfCet II program was to correlate a number of environmental parameters such as selected hydrographic features with cetacean sighting data in an effort to characterize cetacean habitats in the Gulf (Davis et al., 2000). From GulfCet II surveys, sightings of cetaceans along the slope were concentrated in cyclones where production (in this case, measured chlorophyll concentration) was elevated; increased primary production within these cyclonic features enhances secondary production, including preferred prey items. Sightings of these oceanic species, however, were much less frequent in water depths greater than 2,000 m (6,562 ft) and in anticyclones. Sperm whales tended to occur along the mid-to-lower slope, near the mouth of the Mississippi River and, in some areas, in cyclones and zones of confluence between cyclones and anticyclones. From these data, it was suggested that the greater densities of cetaceans sighted along the continental slope, rather than abyssal areas, of the northern Gulf, probably result from localized conditions of enhanced productivity, especially along the upper slope, and as a result of the collisions of mesoscale eddies with the continental margin (Davis et al., 2000).

In the north-central Gulf, the relatively narrow continental shelf south of the Mississippi River delta may be an additional factor affecting cetacean distribution, especially in the case of sperm whales (Davis et al., 2000). Outflow from the Mississippi River mouth transports large volumes of low salinity, nutrient-rich water southward across the continental shelf and over the slope. River outflow may also be entrained within the confluence of a cyclone-anticyclone eddy pair and transported beyond the continental slope. In either case, this input of nutrient-rich water leads to a localized deepwater environment with enhanced productivity and may explain the presence of a resident population of sperm whales within 50 km (31 mi) of the Mississippi River delta in the vicinity of the Mississippi Canyon.

Temporal variability in the distribution of cetaceans in the northern Gulf may also be dependent upon the extent of river discharge and the presence and dynamic nature of mesoscale hydrographic features such as cyclones. Consequently, the distribution of cetacean species will change in response to the movement of prey species associated with these hydrographic features. GulfCet I and II survey data determined that most cetacean species routinely or commonly sighted in the northern Gulf apparently occur in these waters throughout the year. However, seasonal abundance of certain species or species assemblages in slope waters may vary at least regionally (Baumgartner, 1995; Davis et al., 1998a and 2000).

Sirenians

West Indian Manatee (Trichechus manatus)

The West Indian manatee (*Trichechus manatus*) is the only sirenian known to occur in tropical and subtropical coastal waters of the southeastern U.S., Gulf of Mexico, Caribbean Sea, and the Atlantic coast of northern and northeastern South America (Reeves et al., 1992; Jefferson et al., 1993; O'Shea et al., 1995). There are two subspecies of the West Indian manatee: the Florida manatee *(T. m. latirostri*s), which ranges from the northern Gulf of Mexico to Virginia; and the Antillean manatee *(T. m. manatu*s), which ranges from northern Mexico to eastern Brazil, including the islands of the Caribbean Sea.

During warmer months, manatees are common along the west coast of Florida from the Everglades National Park northward to the Suwannee River in northwestern Florida and less common farther westward. In winter, the population moves southward to warmer waters. The winter range is restricted to smaller areas at the southern tip of Florida and to waters near localized warm-water sources, such as power plant outfalls and natural springs in west-central Florida. Crystal River, in Citrus County, is typically the northern limit of the manatee's winter range on the Gulf Coast. Manatees are found at a few small sites farther north. There are 13 winter-aggregation sites on the Florida west coast for manatees (USDOI, FWS, 2001). The major sites are (1) Crystal and Homasassa Rivers (natural springs) (Citrus County), (2) Tampa Electric Company Big Bend Power Plant (Hillsborough County), (3) Florida Power Corporation Bartow Power Plant (Pinellas County), (4) Florida Power & Light Company Fort Myers Power Plant (Lee County), and (5) Port of the Islands Marina (Collier County). The number of manatees, and probably the proportion of the manatee population, using localized warm-water refuges has increased appreciably (MMC, 1999). It is not known to what extent the increasing use of refuges in the Tampa Bay area is due to manatee population growth and/or redistribution of the manatees formerly wintering in southern Florida. Manatees are uncommon along the Florida Panhandle and are infrequently found (strandings and sightings) as far west as Louisiana and Texas (Powell and Rathbun, 1984; Rathbun et al., 1990; Schiro et al., 1998). Several sightings of two different animals were documented in the bays of the Texas Coastal Bend region (centered at Corpus Christi, Texas) during September and November 2001 (Beaver, personal communication, 2001).

Aerial surveys to estimate manatee populations are conducted during colder months when manatees aggregate at warm-water refuges in Florida. There are approximately 1,300 manatees on the Gulf Coast of Florida (Ackerman, personal communication, 1999). One manatee that died in Louisiana waters was determined to be from Tampa Bay, Florida; this determination was based on a photoidentification rematch (Schiro et al., 1998). The manatees occasionally appearing in south Texas waters might be strays from Mexico rather than Florida (Powell and Rathbun, 1984). Few manatees are known to occur along the northeastern coast of Mexico close to Texas (Lazcano-Barrero and Packard, 1989); manatees in south Texas and northern Mexico are probably stragglers from central Mexico. Manatees found in east Texas probably come from Florida.

The Antillean manatee subspecies in Mexico occurs along much of the southeastern Mexican coast from Nautla, Veracruz, to the Belize border and south to Brazil, but it is still reasonably abundant in three principal areas in southeast Mexico: vast wetland systems in the states of Tabasco and Chiapas, the bays and coastal springs along the northern and eastern coasts of the state of Quintana Roo, and the rivers near Alvarado in the state of Veracruz (Lefebvre et al., 1989). A study of manatees in Mexico near the Belize border in Quintana Roo estimates about 200 animals (Ackerman, personal communication, 1999). There are no population estimates for manatees in Mexico on the west side of the Yucatan Peninsula (Campeche) and near the Texas border (Ackerman, personal communication, 1999). There is also no evidence of manatees traveling between Cuba and Florida; it is assumed that the deep Florida Straits are a barrier to regular dispersal.

Two important aspects of manatee physiology influence their behavior and distribution: nutrition and metabolism. Manatees are herbivores that feed opportunistically on a wide variety of submerged, floating, and emergent vegetation (USDOI, FWS, 2001). Distribution of the manatee is limited to low-energy, inshore habitats supporting the growth of seagrasses (Hartman, 1979). Manatees have an unusually low metabolic rate and a high thermal conductance that leads to energetic stresses in winters, which are ameliorated by migrations to warmer areas and aggregations in warm water refugia (Hartman, 1979; O'Shea et al., 1995; Deutsch et al., 1999). Manatees primarily use open coastal (shallow nearshore) areas, estuaries, and are also found far up freshwater tributaries. Shallow grass beds with access to deep channels are preferred feeding areas in coastal and riverine habitats (USDOI, FWS, 2001). Manatees often use secluded canals, creeks, embayments, and lagoons, particularly near the mouths of coastal rivers and sloughs, for feeding, resting, mating, and calving (USDOI, FWS, 2001). Notwithstanding their association with coastal areas, a manatee was documented offshore at several OCS work barges where it was grazing on algae growing on the vessel's sides and bottom. Multiple sightings of the animal were made in October 2001 and occurred in waters exceeding 1,500 m in depth south of Mobile Bay, Alabama. Natural and artificial freshwater areas are sought by manatees occurring in estuarine and brackish areas (USDOI, FWS, 2001) for drinking. Florida manatees can exist for some time without freshwater, but it is believed that they must have access to freshwater periodically to survive (Reynolds and Odell, 1991). It is important that adequate freshwater sources be a component of manatee conservation strategies. Manatee protection has focused on protecting essential manatee habitats (seagrass beds have declined substantially in most parts of the State), as well as reducing direct causes of human-related mortality, injury, and disturbance.

3.2.5. Sea Turtles

Of the seven or eight extant species of sea turtles, five are known to inhabit the waters of the Gulf of Mexico (Pritchard, 1997): the green turtle, the loggerhead, the hawksbill, the Kemp's ridley, and the leatherback (Table 3-37).

As a group, sea turtles possess elongated, paddle-like forelimbs that are modified for swimming and shells that are streamlined (Márquez-M., 1990; Ernst et al., 1994; Pritchard, 1997). Sea turtles spend nearly all of their lives in the water and only depend on land (specifically sandy beaches) as nesting habitat. They mature slowly and are long-lived. Generally, their distributions are primarily circumtropical, although various species differ widely in their seasonal movements, geographical ranges, and behavior. There are also considerable differences in behavior among populations of the same species (Márquez-M., 1990).

Most sea turtles exhibit differential distributions among their various life stages — hatchling, juvenile, and adult (Márquez-M., 1990; Musick and Limpus, 1997; Hirth, 1997). After evacuating a nest and reaching the sea, hatchling turtles swim away from the nesting beach until they encounter zones of watermass convergence and/or sargassum rafts that are rich in prey and provide refuge (USDOC, NMFS and USDOI, FWS, 1991a and b; USDOC, NMFS and USDOI, FWS, 1992; Hirth, 1997). Most then undergo a passive migration, drifting pelagically within prevailing current systems such as oceanic gyres. After a period of years (the number varies among species), juveniles actively move into developmental habitats, which vary by species of sea turtle and are typically located in neritic waters. The term "habitat" is frequently used to communicate two very different perspectives of the concept of "home." When properly used, the term "habitat" actually refers to the "home area" utilized by a single species, population, or even individuals, and should convey both functionality and geographic area. The term is often misused to convey a biotic community that a species sometimes associates with; the correct term for this is "biotope." Examples of biotopes that sea turtles might inhabit as older juveniles include estuaries, bays, and nearshore waters. When approaching maturity, subadult juvenile turtles move into adult foraging areas, which vary among species or populations, and are geographically distinct from their juvenile developmental habitats (Musick and Limpus, 1997). Biotopes that adult sea turtles might forage in include coral reefs, bays, estuaries, nearshore waters, infralittoral, circalittoral, and oceanic waters.

All sea turtle species inhabiting the Gulf of Mexico are listed as either endangered or threatened under the Endangered Species Act of 1973 (Pritchard, 1997). Green, Kemp's ridley, leatherback, and hawksbill sea turtles are currently listed as endangered; the loggerhead sea turtle is currently listed as threatened.

Hard-shell Sea Turtles (Family Cheloniidae)

Green Sea Turtle (Chelonia mydas)

The green sea turtle (*Chelonia mydas*) is the largest hard-shelled sea turtle; adults commonly reach 100 cm in carapace length and 150 kg in weight (USDOC, NMFS, 1990). The green sea turtle is commonly found in tropical and subtropical marine waters with extralimital occurrences generally between latitude 40 ^{o}N. and latitude 40 ^{o}S. (USDOC, NMFS and USDOI, FWS, 1991a; Hirth, 1997). In U.S. Atlantic waters, green sea turtles are found around the U.S. Virgin Islands, Puerto Rico, and Atlantic and Gulf Coasts of the U.S. from Texas to Massachusetts. Areas in Texas and Florida figured heavily in the commercial fishery for green sea turtles at the end of the last century (Hildebrand, 1982).

Green sea turtles primarily occur in coastal waters, where they forage on seagrasses, algae, and associated organisms (Carr and Caldwell, 1956; Hendrickson, 1980). Some green sea turtles may move through a series of "developmental" feeding habitats as they grow (Hirth, 1997). Small pelagic green sea turtles are omnivorous. Adult green sea turtles in the Caribbean and Gulf of Mexico are herbivores, feeding primarily on seagrasses and, to a lesser extent, on algae and sponges. The adult feeding habitats are beds of seagrasses and algae in relatively shallow, protected waters; juveniles may forage in areas such as coral reefs, emergent rocky bottom, sargassum mats, and in lagoons and bays. Areas that are known as important feeding areas for green sea turtles in Florida include the Indian River, Florida Bay, Homosassa River, Crystal River, and Cedar Key (USDOC, NMFS, 1990). Green sea turtles in the Western Gulf are primarily restricted to the Texas coast where seagrass meadows and algae-laden jetties provide them developmental habitat, especially during warmer months (Landry and Costa, 1999). Movements between principal foraging areas and nesting beaches can be extensive, with some populations regularly conducting transoceanic migrations (USDOC, NMFS and USDOI, FWS, 1991a; Ernst et al., 1994; Hirth, 1997).

Statewide in Florida, nesting has been reported for greens as early as April 28 and as late as October 3 (Meylan et al., 1995). Most nesting by green turtles in recent decades for Florida has been recorded on the southeast coast. There are historic and recent records of green turtle presence in southwest Florida (summary in Meylan et al., 1995). In the Florida Panhandle, nesting has been recorded at Eglin Air Force Base in Okaloosa County (Meylan et al., 1995). The number of nests in Florida appears to be increasing, but whether this upward trend is due to an increase in the number of nests or is a result of more thorough monitoring of the nesting beaches is uncertain (USDOC, NMFS, 1990; Meylan et al., 1995).

Hawksbill Sea Turtle (Eretmochelys imbricata)

The hawksbill (*Eretmochelys imbricata*) is a small- to medium-sized sea turtle that occurs in tropical to subtropical waters of the Atlantic, Pacific, and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean. In the continental U.S., the hawksbill has been recorded in coastal waters of each of the Gulf States and along the Atlantic coast from Florida to Massachusetts (USDOC, NMFS, 1993), although sightings north of Florida are rare (Hildebrand, 1982). They are considered to be the most tropical of all sea turtle species and the least commonly reported sea turtle species occurring in the Gulf (Márquez-M., 1990; Hildebrand, 1995).

Coral reefs are generally recognized as the resident foraging habitat for both juveniles and adults. Adult hawksbills feed primarily on sponges (Carr and Stancyk, 1975; Meylan, 1988) and demonstrate a high degree of selectivity, feeding on a relatively limited number of sponge species, primarily demosponges (Ernst et al., 1994).

Texas and Florida are the only states in the U.S. where hawksbills are sighted with any regularity (USDOC, NMFS, 1993). Stranded hawksbills have been reported in Texas (Hildebrand, 1982; Amos, 1989) and in Louisiana (Koike, 1996); these tend to be either hatchlings or yearlings. A hawksbill was captured accidentally in a purse seine net just offshore Louisiana (Rester and Condrey, 1996). Hawksbills found stranded in Texas are believed to originate from nesting beaches in Mexico (Landry and Costa, 1999). Northerly currents may carry immature hawksbills away from their natal beaches in Mexico northward into Texas (Amos, 1989; Collard and Ogren, 1990). Offshore at the Flower Garden Banks National Marine Sanctuary, seven sightings of the hawksbill were made between 1994 and 2000 (Hickerson, 2000). Hickerson (2000) determined that Stetson Bank, a midshelf bank that is part of the Flower Garden Banks National Marine Sanctuary, is more suitable habitat to the hawksbill sea turtle than either the East or West Flower Garden Bank. More recently, scientific divers at Stetson Bank observed an adult hawksbill sea turtle during the warmer months of 2001 (Hickerson et al., personal communication, 2001).

The hawksbill turtle is a solitary nester. Nesting within the continental U.S. is limited to southeastern Florida and the Florida Keys. Nesting by hawksbills in Florida is considered rare. Statewide, nesting has been reported as early as June 6 and as late as October 31 (Meylan et al., 1995). Juvenile hawksbills show evidence of residency on specific foraging grounds, although hawksbill migrations are possible (USDOC, NMFS and USDOI, FWS, 1993). Some populations of adult hawksbills undertake reproductive migrations between foraging grounds and nesting beaches (Márquez-M., 1990; Ernst et al., 1994). The hawksbill is presently listed as an endangered species.

Kemp's Ridley Sea Turtle (Lepidochelys kempi)

The Kemp's ridley (*Lepidochelys kempi*) is the smallest sea turtle species and occurs chiefly in the Gulf of Mexico. It may also be found along the northwestern Atlantic coast of North America as far north as Newfoundland. It is the most imperiled of the world's sea turtles. The Gulf of Mexico's population of nesting females has dwindled from an estimated 47,000 in 1947 to a current nesting population of approximately 4,200 females (Shaver, personal communication, 2001). A population crash that occurred between 1947 and the early 1970's may have been the result of both intensive annual harvest of the eggs and mortality of juveniles and adults in trawl fisheries (NRC, 1990). The recovery of the Kemp's ridley from the threat of extinction has been forestalled primarily by mortality associated with the commercial shrimp fishery (USDOI, FWS and USDOC, NMFS, 1992).

In the northern Gulf, Kemp's ridleys are most abundant in coastal waters from Texas to west Florida (Ogren, 1989; Márquez-M., 1990 and 1994; Rudloe et al., 1991). Kemp's ridleys display strong seasonal fidelity to tidal passes and adjacent beachfront environs of the northern Gulf (Landry and Costa, 1999). There is little prolonged utilization of waters seaward of the 50-m isobath by this species (Renaud, 2001). Adult Kemp's ridley turtles usually occur only in the Gulf, but juvenile and immature individuals sometimes range between tropical and temperate coastal areas of the northwestern Atlantic and Gulf (Márquez-M., 1990). Juveniles are more common than adults along the East Coast of the U.S., from Florida to New England and especially off Florida and Georgia. Within the Gulf, juvenile and immature Kemp's ridleys have been documented along the Texas and Louisiana coasts, at the mouth of the Mississippi River, and along the west coast of Florida, as quoted in stranding reports, (Ogren, 1989; Márquez-M., 1990).

The primary nesting area utilized by the Kemp's ridley sea turtle is near Rancho Nuevo, along the northeastern coast of Mexico in the state of Tamaulipas (USDOI, FWS and USDOC, NMFS, 1992, Márquez-M. et al., 2001), although secondary nest areas have also been reported in other areas of Mexico, Texas (specifically south Texas), Florida, and South Carolina (USDOI, FWS and USDOC, NMFS, 1992; Ernst et al., 1994; Márquez-M. et al., 2001). Eggs are laid annually, and following the nesting season, the adults disperse towards two feeding grounds: one northwest toward Florida and the other southeast to the Campeche Bank off the Yucatan Peninsula of Mexico. Some adult female Kemp's ridley sea turtles tagged at Rancho Nuevo have been recorded off Louisiana and Mississippi (Márquez-M., 1994). Two adult females bearing flipper tags applied at the Rancho Nuevo nesting beach were recaptured at Calcasieu and Sabine Passes, Louisiana. These post-nesting females may have been in transit to shallow Gulf foraging areas to begin conditioning for their next reproductive cycle (Landry and Costa, 1999). Post-nesting females have also been tagged in Texas, and 17 of the 18 animals tagged with satellite transmitters between 1997 and 2001 were discovered to spend time in waters along at least one of the Gulf States (Shaver, personal communication, 2001). Only one post-nesting female that was tagged with a satellite transmitter in Texas moved south to Mexican waters (Shaver, personal communication, 2001). Juveniles, subadults, and adults are common off Big Gulley, an offshore area east of Mobile Bay, Alabama, where they have been sometimes captured in trawls since the mid-1970's (Carr, 1980; Ogren, 1989; Márquez-M., 1994). Some of the smallest Kemp's ridley sea turtles have been found off Wakulla and Franklin Counties, Florida (Ogren, 1989). Two sightings of Kemp's ridley turtles were reported over the continental shelf in the Eastern Gulf during GulfCet II surveys (Davis et al., 2000).

Nesting in the U.S. occurs annually on Padre and Mustang Islands in south Texas from May to August (Thompson, 1988). A multiagency program initiated in 1978 to establish a secondary nesting colony in south Texas supplemented natural nesting. From 1948 through 1998, 45 Kemp's ridley nests on the Texas coast were documented (Shaver and Caillouet, 1998). Only 11 Kemp's ridley nests were found in Texas from 1979 to 1995 (Shaver, 1995). The first documented nesting of living-tagged Kemp's ridley in 1996 is the first documentation of any sea turtle nesting at an experimental imprinting site and outside of captivity after being released from a head-starting program (Shaver, 1996a and b). During the 1998 nesting season, 13 confirmed Kemp's ridley nests were found on the Texas coast (Shaver and Caillouet, 1998). A record 16 Kemp's ridley nests were found on Texas beaches during 1999. Twelve nests were documented in Texas during 2000; however, only eight Kemp's ridley nests were located in Texas during the 2001 nesting season (Shaver, personal communication, 2001).

The first confirmed nesting in the U.S. of a Kemp's ridley turtle that had previously nested in Mexico occurred in 1998 (Shaver and Caillouet, 1998). Kemp's ridleys that nest in south Texas today are likely a mixture of returnees from the experimental imprinting and head-starting project and others from the wild stock. Kemp's ridley sea turtles have been also documented nesting in Alabama and Florida, although less frequently than on Texas beaches. In 1998, one nest was confirmed in Alabama on Bon Secour National Wildlife Refuge (Baldwin County) (MacPherson, personal communication, 2000). In the same year, another nesting site was confirmed on Gulf Islands National Seashore (GINS) (Perdido Key Area, Escambia County, Alabama) (Nicholas, personal communication, 2000). Kemp's ridley turtles have occasionally nested in Florida. There are two reports for Pinellas County, Florida: one on Madeira Beach in 1989 (Meylan et al., 1990) and the second on Clearwater Beach in 1994 (Anonymous, 1994). There were two nests for Volusia County on the southeast coast of Florida (May 14 and June 1, 1996) (Johnson et al., 2000). The Kemp's ridley sea turtle nesting and hatching season for northwest Florida beaches extends from May 1 through October 31. For the one confirmed nest on GINS, the nest was laid on May 31 and eggs hatched on August 3, for an incubation period of 64 days (Nicholas, personal communication, 2000). Two adult female Kemp's ridleys found at Padre Island were satellite tagged to document post-nesting movements (Shaver, personal communication, 1998). Both females moved northward, spending most of their time in Louisiana waters; one female moved as far as western Florida, the other stayed in the vicinity of Louisiana.

Hatchlings appear to disperse offshore and are sometimes found in sargassum mats (Collard and Ogren, 1990). Two juvenile Kemp's ridleys released through the headstart program of the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries), formerly known as NMFS, were found drifting in sargassum: one was found 46.3 km south of Mobile, Alabama; the other 4.6 km off Horseshoe and Pepperfish Keys on the north-central Gulf Coast of Florida (Manzella et al., 1991). During the pelagic life history stage, the Kemp's ridley sea turtle is dependent on currents, fronts, and gyres to determine their distribution. Hatchling and small juvenile habitats are hardly known due to lack of information. Some young turtles stay within the Gulf, whereas others are carried by currents out of the Gulf into the Gulf Stream current and up to the northeastern U.S. The latter migrate south and enter the Gulf as they approach maturity. With growth, the turtles actively move to shallow coastal waters, especially off western Louisiana and eastern Texas or off northwestern Florida, where feeding on benthos occurs. The north and northeast portions of the northern Gulf are considered foraging habitat for juveniles, subadults, and post-nesting females (Ogren, 1989; Rudloe et al., 1991). The Kemp's ridleys inhabiting the upper Texas and Louisiana coastal waters utilize sandy and muddy bottoms, feeding on portunids and other crabs (Ogren, 1989; Shaver, 1991), and possibly on bycatch generated by the shrimp fishery (Landry and Costa, 1999). Other Kemp's ridleys move to Cedar Key, Florida, an area where they also prey on portunid crabs. This is an area where seagrass communities are common, and also where Kemp's ridleys penetrate bays and estuaries (Carr and Caldwell, 1956; Lutcavage and Musick, 1985; Landry, personal communication, 2000). Strandings of Kemp's ridleys on Texas beaches indicate that they are mostly from Mexico (Shaver, personal communication, 1998).

Loggerhead Sea Turtle (Caretta caretta)

The loggerhead (*Caretta caretta*) is a large sea turtle that inhabits temperate and tropical marine waters of the Atlantic, Pacific, and Indian Oceans. This species is wide-ranging throughout its range and is capable of living in varied habitat types for a relatively long time (Márquez-M., 1990; USDOC, NMFS and USDOI, FWS, 1991b; Ernst et al., 1994). Loggerheads feed primarily on benthic invertebrates but are capable of feeding on a wide range of food items (Ernst et al., 1994). The loggerhead is the most abundant species of sea turtle occurring in U.S. waters of the Atlantic, from Florida to Cape Cod, Massachusetts. The loggerhead is probably the most common sea turtle species in the northern Gulf (e.g., Fritts et al., 1983; Fuller and Tappan, 1986; Rosman et al., 1987b; Lohoefener et al., 1990) and is currently listed as a threatened species.

In the western North Atlantic, there are at least four loggerhead nesting subpopulations: the Northern Nesting Subpopulation (North Carolina to northeast Florida, about 29° N. latitude); the South Florida Nesting Subpopulation (29° N. latitude to Naples); the Florida Panhandle Nesting Subpopulation (Eglin Air Force Base and the beaches near Panama City); and the Yucatán Nesting Subpopulation (northern and eastern Yucatán Peninsula, Mexico) (Byles et al., 1996). Based upon the returns of tags applied at nesting beaches, non-nesting adult females from the South Florida Subpopulation are distributed throughout the Bahamas, Greater Antilles, Yucatán, Eastern Gulf of Mexico, and southern Florida (Meylan, 1982). Non-nesting adult females from the Northern Subpopulation occur occasionally in the northeastern Gulf (Meylan, 1982). Limited tagging data suggest that adult females nesting in the Gulf of Mexico remain in the Gulf (Meylan, 1982). Little information is available on adult male distribution; however, they have been observed year-round in south Florida (Byles et al., 1996). Little is known about seasonal movements of loggerheads in the Gulf (Byles et al., 1996). The largest nesting concentration in the U.S. is on the southeast Florida coast from Volusia to Broward Counties. Statewide in Florida, nesting has been reported for loggerheads as early as March 16 and as late as October 16 (Meylan et al., 1995).

Loggerheads are the most common nesting sea turtle in northwest Florida and account for over 99 percent of the nests. The loggerhead sea turtle nesting and hatching season for northwest Florida beaches generally extends from about May 1 through October 31. The earliest nest was documented on April 27 and the latest nest on November 1. Nest incubation ranges from about 49 to 95 days. On the Gulf Coast of Florida, the most nesting by loggerheads occurs from Pinellas through Monroe Counties (southwest Florida) and from Escambia through Franklin Counties (northwest Florida). Data gathered in surveys along the Florida Gulf Coast (1998-2000 seasons) indicate that approximately 87 percent of the loggerhead nests reported were made in the southwest counties and approximately 13 percent were in northwest counties (Patrick, personal communication, 2001; Brost, personal communication, 2001). The greatest abundance of loggerhead nests found per region was in Sarasota and Charlotte Counties (southwest Florida), and Bay, Gulf, and Franklin Counties (northwest Florida).

On the Central Gulf Coast, limited monitoring of nesting activity has been conducted. A total of 107 loggerhead nests were documented during the 1999 and 2000 nesting seasons on the Bon Secour National Wildlife Refuge to Mobile Bay (Swilling, personal communication, 2001). Loggerhead nesting was reported at Biloxi, Mississippi, in 1991 (South and Tucker, personal communication, 1991). It is unknown whether the nesting sea turtles in Alabama, Mississippi, and Louisiana are genetically distinct subpopulations or genetically similar to the Florida Panhandle Subpopulation (Bowen et al., 1993).

Nesting in Texas occurs primarily on North and South Padre Islands, although occurrences are recorded throughout coastal Texas (Hildebrand, 1982).

Based on aerial survey results, western North Atlantic loggerheads are distributed about 54 percent in the southeast U.S. Atlantic, 29 percent in the northeast U.S. Atlantic, 12 percent in the eastern Gulf of Mexico, and 5 percent in the western Gulf of Mexico (Byles et al., 1996). Aerial surveys indicate that loggerheads are largely abundant in water depths less than 100 m (Shoop et al., 1981; Fritts et al., 1983). During the GulfCet aerial surveys, loggerheads were sighted throughout the northern Gulf continental shelf waters near the 100-m isobath (Davis et al., 2000). Loggerheads were also sighted over very deep waters (>1,000 m). Sightings indicate that loggerhead distribution is not as coastal-associated as that of Kemp's ridley and green sea turtles (Landry and Costa, 1999). Loggerheads have also been sighted seaward of the shelf break in the northeast U.S. (Shoop and Kenney, 1992). Loggerhead abundance in continental slope waters of the eastern Gulf increased appreciably during winter (Davis et al., 2000). It is not clear why adult loggerheads would occur in oceanic waters, unless they were traveling between foraging sites in distant and separate areas on the continental shelf or seeking warmer waters during winter (Davis et al., 2000). Shoop et al. (1981) suggested that loggerheads in oceanic waters off the Atlantic coast of the U.S. were probably in transit to other areas. Witzell and Azarovitz (1996) suggested that some turtles may move offshore in winter to seek warm-core eddies.

Loggerheads have been found to be abundant in Florida waters (Fritts and Reynolds, 1981; Fritts et al., 1983; Davis et al., 2000). Underwater surveys made near artificial reefs and a sunken offshore platform near Panama City, Florida, noted 17 sightings of sea turtles. All turtles sighted were loggerheads, usually resting in a shallow pit in the sand at a place where the artificial reef formed a sheltering overhang (Rosman et al., 1987b). In the Central Gulf, loggerheads are very abundant just offshore Breton and Chandeleur Islands (Lohoefener et al., 1990). Individual subadult loggerheads tagged with satellite transmitters at the Flower Garden Banks near the shelf-edge off Texas were found to persist there over several years (Hickerson, 2000).

Juvenile and subadult loggerheads are omnivorous, foraging on pelagic crabs, molluscs, jellyfish, and vegetation captured at or near the surface (Dodd, 1988; Plotkin et al., 1993). Adult loggerheads forage on benthic invertebrates (Dodd, 1988). The banks off central Louisiana and near the Mississippi Delta are also important marine turtle feeding areas (Hildebrand, 1982). Subadult loggerheads utilize the Flower Garden Banks near the shelf-edge off Texas as feeding habitat during all seasons (Hickerson, 2000). Genetic evidence has suggested that at least two of the subpopulations intermingle on the foraging grounds of the U.S. Atlantic coast (Byles et al., 1996).

Leatherback Sea Turtle (Family Dermochelyidae)

Leatherback Sea Turtle (Dermochelys coriacea)

The leatherback (*Dermochelys coriacea*) is the largest and most distinctive sea turtle. This species possesses a unique skeletal morphology, most evident in its flexible, ridged carapace, and in cold water maintains a core body temperature several degrees above ambient. They also have unique deep-diving abilities (Eckert et al., 1986). This species is the most wide-ranging sea turtle, undertaking extensive migrations from the tropics to boreal (cold-temperate regions of the northern latitudes) waters (Morreale et al., 1996; Hughes et al., 1998). Though considered oceanic, leatherbacks will occasionally enter bays and estuaries (Hoffman and Fritts, 1982; Knowlton and Weigle, 1989; Shoop and Kenney, 1992). Using satellite telemetry, it was recently determined that female leatherback turtles migrating through the Pacific Ocean are using similar and in some cases virtually identical pathways or ocean corridors to travel (Morreale et al., 1996). Leatherbacks feed primarily on gelatinous zooplankton such as jellyfish, siphonophores, and salps (Brongersma, 1972), although they may ingest some algae and vertebrates (Ernst et al., 1994). Leatherbacks' stomach contents have been analyzed and data suggest that they may feed at the surface, at depth within deep scattering layers, or on the benthos. Florida is the only site in the continental U.S. where leatherbacks regularly nest (USDOC, NMFS and USDOI, FWS, 1992b; Ernst et al., 1994; Meylan et al., 1995). The leatherback is currently listed as an endangered species.

Sightings of leatherbacks are common in oceanic waters of the northern Gulf of Mexico (Leary, 1957; Fritts et al., 1983; Lohoefener et al., 1988 and 1990; Collard, 1990; Davis et al., 2000). Based on a summary of several studies, Davis and Fargion (1996) concluded that the primary habitat of the leatherback in the northwestern Gulf is oceanic waters (>200 m). In contrast, the overall densities of leatherbacks in the Eastern Gulf on the shelf and on the slope were similar (Davis et al., 2000). It has been suggested that the region from Mississippi Canyon east to DeSoto Canyon appears to be an important habitat area for leatherbacks (Davis and Fargion, 1996). Most of the sightings of leatherbacks during the GulfCet surveys occurred slightly north of DeSoto Canyon (Davis and Fargion, 1996; Davis et al., 2000). The nearly disjunct summer and winter distributions of leatherback sightings over the continental slope in the Eastern Gulf during GulfCet II indicate that specific areas may be important to this species either seasonally or for short periods of time. These specific locations are most probably correlated with oceanographic conditions and resulting concentrations of prey. Large numbers of leatherbacks in waters off the northeast U.S. have been associated with concentrations of jellyfish (Shoop and Kenney, 1992). Similar sightings with high jellyfish abundance have been made in the Gulf: 100 leatherbacks were sighted just offshore Texas, while 7 were seen at a watermass boundary in the Eastern Gulf (Leary, 1957; Collard, 1990). Other clustered sightings of leatherbacks have been reported for the northern Gulf: 8 leatherbacks were sighted one day in DeSoto Canyon (Davis and Fargion, 1996), 11 during one day just south of the Mississippi River Delta (Lohoefener et al., 1990), and 14 during another day in DeSoto Canyon (Lohoefener et al., 1990).

Leatherback nesting is concentrated on coarse-grain beaches in the tropical latitudes (Pritchard, 1971). Analysis of haplotype frequencies has revealed that nesting populations of leatherbacks are strongly subdivided globally, despite the leatherback's highly migratory nature (Dutton et al., 1999). Those findings provisionally support the natal homing hypothesis for leatherbacks. Leatherbacks nest annually in U.S. territories within the Caribbean, principally at St. Croix (U.S. Virgin Islands) and Isla Culebra (Puerto Rico) (USDOC, NMFS and USDOI, FWS, 1992). Critical habitat for the leatherback includes the waters adjacent to Sandy Point, St. Croix. Additionally, leatherback sea turtles nest on beaches in Georgia and Florida. Based on an average of 5-7 nests per female per season observed at other rookeries, Meylan et al. (1995) estimated there to be 16-31 individual leatherbacks nesting annually in small numbers on the east coast of Florida.

On the Gulf Coast of Florida, documented leatherback nests are rare. One leatherback nest was reported between Phillips Inlet and Destin in September 1962 (Yerger, 1965). Another leatherback nest was documented in 1974 on St. Vincent Island, Franklin County. From 1993 to 2000, only 15 nests were reported—10 in Franklin County, 3 in Okaloosa County, 1 each in Gulf and Escambia Counties (Brost, personal communication, 2001). The greatest number of nests documented in any one season occurred in 2000, when leatherback nesting was confirmed (including successful hatching) of one nest on Gulf Islands National Seashore (Ft. Pickens Unit, Escambia County) and two nests on Eglin Air Force Base (Okaloosa Island, Okaloosa County).

Nesting occurs from February through July from Georgia to the U.S. Virgin Islands. The leatherback sea turtle nesting and hatching season for northwest Florida beaches extends from May 1 through October 31. For confirmed nesting, the earliest nest was documented on April 29 and the latest nest documented on June 19. Documented nest incubation in northwest Florida ranges from about 63 to 84 days (Brost, personal communication, 2001; Miller, personal communication, 2001; Nicholas, personal communication, 2001). Statewide in Florida, nesting has been reported for leatherbacks as early as February 22 (Meylan et al., 1995). Although the number of leatherback sea turtles nesting on Florida beaches is small relative to those nesting in St. Croix and Puerto Rico, it is the only nesting habitat regularly utilized by this endangered species in the continental U.S.

Distributions of Sea Turtles in the Offshore Waters of the Northern Gulf of Mexico

Surveys conducted during the GulfCet I and II studies represent the most recent assessments of sea turtle distribution and abundance within the oceanic northern Gulf (Davis et al., 1998a and 2000). During these surveys, only three species of sea turtles were sighted: loggerheads, Kemp's ridleys, and leatherbacks.

The GulfCet I and II surveys found the abundance of sea turtles in the northern Gulf of Mexico to be considerably higher over the continental shelf and within the eastern Gulf, east of Mobile Bay (Lohoefener et al., 1990; Davis et al., 2000). Kemp's ridleys were sighted only along the shelf. Sightings of loggerheads were also considerably higher over the continental shelf than the continental slope. However, there were sightings of loggerheads in waters exceeding 1,000 m in depth. The importance of oceanic habitat to loggerheads was not clear from these surveys, though it was suggested that turtles may move through these waters to distant foraging sites or while seeking warmer waters during winter (Davis et al., 2000). From historic sighting data, leatherbacks appear to utilize both shelf and slope habitat areas in the northern Gulf (Fritts et al., 1983; Collard, 1990; Davis et al., 1998a). GulfCet I and II studies suggested that the region from Mississippi Canyon to DeSoto Canyon, especially near the shelf edge, may be important habitat for leatherbacks (Davis et al., 2000).

Seasonally, loggerheads were widely distributed across the continental shelf during both summer and winter, though their abundance over the continental slope was considerably higher during winter surveys than summer (Davis et al, 2000). Temporal variability in leatherback distribution and abundance suggest that specific areas may be important to this species, either seasonally or for short periods of time. Overall, leatherbacks occurred in substantial numbers during both summer and winter surveys, and the high variability in the relative numbers of individual leatherbacks sighted within specific areas suggest that their distribution patterns were irruptive in nature (Davis et al., 2000).

3.2.6. Alabama, Choctawhatchee, St. Andrew, and Perdido Key Beach Mice

Hall (1981) recognizes 16 subspecies of field mouse (*Peromyscus polionotus*), 8 of which are collectively known as beach mice. Of Gulf Coast subspecies, the Alabama, Choctawhatchee, St. Andrew, and Perdido Key, beach mice occupy restricted habitats in the mature coastal dunes of Florida and Alabama. All four mice are listed as endangered: the Alabama subspecies in Alabama, and the Perdido Key, St. Andrew, and Choctawhatchee subspecies in Florida (USDOI, FWS, 1987). Populations have fallen to levels approaching extinction. For example, in the late 1980's, estimates of total remaining beach mice were less than 900 for the Alabama beach mouse, about 80 for the Perdido Key beach mouse, and about 500 for the Choctawhatchee beach mouse. The Alabama, Perdido Key, and Choctawhatchee beach mice were listed as endangered in the 1980's. The St. Andrew beach mouse was not listed as endangered until 1998; it is the only listed subspecies without designated critical habitat. Continued monitoring of populations of all subspecies along the Gulf Coast between 1985 and the present indicates that approximately 52 km (32.3 mi) of coastal dune habitat are now occupied by the four listed subspecies (1/3 of historic range). Beach mice were listed because of the loss of coastal habitat from human development. The reduced distribution and numbers of beach mice have continued because of multiple habitat threats over their entire range (coastal development and associated human activities, military activities, coastal erosion, and weather). The *Federal Register* (1985a) cites habitat loss as the primary cause for declines in populations of beach mice. Development of beachfront real estate along coastal areas and catastrophic alteration by hurricanes are the primary contributors to loss of habitat. Destruction of Gulf Coast sand dune ecosystems for commercial and residential development has destroyed about 60 percent of original beach mouse habitat.

The inland extent of beach mouse habitat may vary depending on the configuration of the sand dune system and the vegetation present. There are commonly several rows of dunes paralleling the shoreline and within these rows there are generally three types of microhabitat. The first microhabitat is the frontal dunes, which are sparsely vegetated with widely scattered coarse grasses including sea oats (*Uniola paniculata*), bunch grass (*Andropogon maritimus*), and beach grass (*Panicum amarum* and *P. repens*), and with seaside rosemary (*Ceratiola ericoides*), beach morning glory (*Ipomoea stolonifera*), and railroad vine (*I. Pes-caprae*). The second microhabitat is the frontal dune grasses, a lesser component on the higher rear scrub dunes, which support growth of slash pine (*Pinus elliotti*), sand pine (*P. clausa*), and scrubby shrubs and oaks, including yaupon (*Ilex vomitoria*), marsh elder (*Iva sp.*), scrub oak (*Quercus myrtifolia*), and sand-live oak (*Q. virginiana* var. *maritima*). The third microhabitat is the interdunal areas, which contain sedges (*Cyperus sp.*), rushes (*Juncus scirpoides*), and salt grass (*Distichlis spicata)*.

Beach mice are restricted to the coastal barrier sand dunes along the Gulf. Optimal overall beach mouse habitat is currently thought to be comprised of a heterogeneous mix of interconnected habitats including primary dunes, secondary dunes, scrub dunes, and interdunal areas. Beach mice dig burrows mainly in the primary, secondary, and interior scrub dunes where the vegetation provides suitable cover. Most beach mouse surveys conducted prior to the mid-1990's were in primary and secondary dunes because the investigators assumed that these habitats are the preferred habitat of beach mice. A limited number of surveys in scrub dunes and other interior habitat resulted in less knowledge of the distribution and relative abundance there. In coastal environments, the terms "scrub" and "scrub dune" refer to habitat or vegetation communities adjacent to and landward of primary and secondary dune types where scrub oaks are visually dominant. Interior habitat can include vegetation types such as grass-like forbs (forbs are the herbs other than grasses). There is substantial variation in scrub oak density and cover within and among scrub dunes throughout ranges of beach mice. The variation, an ecological gradient, is represented by scrub oak woodland with a relatively closed canopy at one end of a continuum. At the other extreme of the gradient, scrub dunes are relatively open with patchy scrub ridges and intervening swales or interdunal flats dominated by herbaceous plants.

Beach mice feed nocturnally in the dunes and remain in burrows during the day. Their diets vary seasonally but consist mainly of seeds, fruits, and insects (Ehrhart, 1978; Moyers, 1996). Changes in the availability of foods result in changes in diets between seasons and account for variability of seasonal diets between years. Autumn diets of beach mice consist primarily of seeds and/or fruits of sea oats, evening primrose (*Oenothera humifusa*), bluestem (*Schizachyrium maritimum*), and dune spurge (*Chamaesyce ammannioides*). Sea oats and beach pea (Galactia sp.) dominate winter diets. Spring diets primarily consist of dune toadflax (*Linaria floridana*), yaupon holly (*Ilex vomitoria)*, seashore elder (*Iva imbricata*), and greenbrier (*Smilax sp.*). Summer diets are dominated by evening primrose, insects, dune toadflax, and ground cherry (*Physalis augustifolia*) (Moyers, 1996). Management practices designed to promote recovery of dune habitat, increase food sources, and enhance habitat heterogeneity may aid in recovery of beach mouse populations.

In wild populations, beach mice have an average life span of about nine months. Males and females reach adulthood and are able to reproduce at approximately 35 days of age. Females can nurse one litter while pregnant with another litter. From captive colonies we know that litter size is 1-8 with an average of four. Young are weaned in 2-3 weeks and are generally on their own 1-2 weeks later.

Hurricanes are a natural environmental phenomenon affecting the Gulf Coast, and beach mice have evolved and persisted in coastal dune habitats since the Pleistocene. Hurricanes are part of a repeated cycle of destruction, alteration, and recovery of dune habitat. The extensive coastal dune habitat that existed along the Gulf Coast before the fairly recent commerical and residential development allowed beach mice to survive even the most severe hurricane events to repopulate dune habitat as it recovered. Beach mice are affected by the passage of hurricanes along the northwest Florida and Alabama Gulf Coast. Since records on hurricane intensity began in 1885, a total of 32 hurricanes have struck northwest Florida within the historic ranges of the four Gulf Coast beach mouse subspecies (Williams and Duedall, 1997; Doehring et al., 1994; Neumann et al., 1993). In addition, since 1899, a total of 11 hurricanes have hit the coast of Alabama.

Hurricanes generally produce damaging winds, storm tides and surges, and rain that erode barrier-island, peninsular, and mainland beaches and dunes. Following hurricanes, the dune system begins a slow natural repair process that may take 3-20 years, depending on the magnitude of dune loss (Salmon et al., 1982). During this period, sea oats and pioneer dune vegetation become established, collecting sand and building dunes. As the dunes grow and become stable, other successional dune vegetation colonizes the area (Gibson and Looney, 1994), and beach mouse food sources and habitats are reestablished. The rate of recovery of food supplies for beach mice is variable with some areas adversely affected for an extended period of time by a hurricane and post-hurricane conditions.

Tropical storms periodically devastate Gulf Coast sand dune communities, dramatically altering or destroying habitat, and either drowning beach mice or forcing them to concentrate on high scrub dunes where they are exposed to predators. How a hurricane affects beach mice depends primarily on its characteristics (winds, storm surge, rainfall), the time of year (midsummer is the worst), and where the eye crosses land (side of hurricane—clockwise or counterclockwise), population size, and storm impacts to habitat and food sources. The interior dunes and related access corridors may be essential habitats for beach mice following survival of a hurricane. For the three subspecies that have critical habitat areas (Alabama, Perdido Key, and Choctawhatchee beach mice), the major constituent elements that are known to require special management considerations or protection are dunes and interdunal areas and associated grasses and shrubs that provide food and cover (USDOI, FWS, 1985a and b).

Beach mice have existed in an environment subject to recurring hurricanes, but tropical storms and hurricanes are now considered to be a primary factor in the beach mouse's decline. It is only within the last 20-30 years that the combination of habitat loss to beachfront development, isolation of remaining habitat blocks and beach mouse populations, and destruction of remaining habitat by hurricanes have increased the threat of extinction of several subspecies of beach mice.

Reasons for Current Status

Beachfront development continues to be the greatest threat. The combinations of habitat loss to beachfront development, isolation of remaining habitat blocks and beach mouse populations, and destruction of remaining habitat by hurricanes has increased the threat of extinction of several subspecies of beach mice. Habitat reduction and fragmentation have affected the ability of beach mice to quickly recover following tropical storms and have become a major threat to the recovery of the three subspecies.

3.2.7. Coastal and Marine Birds

3.2.7.1. Nonendangered and Nonthreatened Species

The offshore waters, coastal beaches, and contiguous wetlands of the northern Gulf of Mexico are populated by both resident and migratory species of coastal and marine birds. They are herein separated into five major groups: diving birds, shorebirds, marsh birds, wading birds, and waterfowl. Many species are mostly pelagic, and therefore rarely sighted nearshore. The remaining species are found within coastal and inshore habitats and are more susceptible to potential deleterious effects resulting from OCS-related activities (Clapp et al., 1982). Recent surveys indicate that Louisiana and Texas are among the primary states in the southern and southeastern U.S. for nesting colony sites and total number of nesting coastal and marine birds (Martin and Lester, 1991; Martin, 1991). Fidelity to these nesting sites varies from year to year along the Gulf Coast. Site abandonment along the northern Gulf Coast has often been attributed to habitat alteration and excessive human disturbance (Martin and Lester, 1991).

Diving birds are a diverse group. There are three main groups of diving birds: cormorants and anhingas (Pelecaniformes), loons (Gaviiformes), and grebes (Podicipediformes). Nesting diving birds on the Gulf include cormorants.

Gulls, terns, and black skimmers make up the gull/tern group. Of these, colonies of laughing gulls, eight species of terns, and black skimmers nest in the Gulf (Martin and Lester, 1991; Pashley, 1991).

Shorebirds are those members of the order Charadriiformes generally restricted to coastline margins (beaches, mudflats, etc.). Gulf of Mexico shorebirds comprise five taxonomic families—Jacanidae (jacanas), Haematopodidae (oystercatchers), Recurvirostridae (stilts and avocets), Charadriidae (plovers), and Scolopacidae (sandpipers, snipes, and allies) (Hayman et al., 1986). An important characteristic of almost all shorebird species is their strongly developed migratory behavior, with some shorebirds migrating from nesting places in the far north to the southern part of South America (Terres, 1991). Both spring and fall migrations take place in a series of "hops" to staging areas where birds spend time feeding heavily to store up fat for the sustained flight to the next staging area; many coastal habitats along the Gulf of Mexico are critical for such purposes. Along the central Gulf Coast, 44 species of shorebirds have been recorded; only 6 nest in the area, the remaining are wintering residents and/or "staging" transients (Pashley, 1991). Although variations occur between species, most shorebirds begin breeding at one to two years of age and generally lay 3-4 eggs per year. They feed on a variety of marine and freshwater invertebrates and fish, and small amounts of plant life.

Collectively, the following families of wading birds have representatives in the northern Gulf: Ardeidae (herons and egrets), Ciconiidae (storks), Threskiornithidae (ibises and spoonbills), and Gruidae (cranes). Wading birds are those birds that have adapted to living in shallow water. They have long legs that allow them to forage by wading into shallow water, while their long bills, usually accompanied by long necks, are used to probe under water or to make long swift strokes to seize fish, frogs, aquatic insects, crustaceans, and other prey (Terres, 1991). The term "marsh bird" is a general term for a bird that lives in or around marshes and swamps. Seventeen species of wading birds in the Order Ciconiiformes are currently known to nest in the U.S., and all except the wood stork nest in the northern Gulf coastal region (Martin, 1991). Within the central Gulf Coast region, Louisiana supports the majority of nesting wading birds. Great egrets are the most widespread nesting species in the central Gulf region (Martin, 1991), while little blue herons, snowy egrets, and tricolored herons constitute the greatest number of coastal nesting pairs in the western Gulf Coast (Texas Parks and Wildlife Department, 1990). Members of the Rallidae family (rails, moorhens, gallinules, and coots) have compact bodies, and therefore, they are labeled marsh birds and not wading birds. They are also elusive and rarely seen within the low vegetation of fresh and saline marshes, swamps, and rice fields (Bent, 1926; National Geographic Society, 1983; Ripley and Beehler, 1985).

Waterfowl belong to the taxonomic order Anseriformes and include swans, geese, and ducks. A total of 36 species are regularly reported along the north-central and western Gulf Coast, consisting of 1 swan, 5 geese, 11 surface-feeding (dabbling) ducks and teal, 5 diving ducks (pochards), and 14 others (including the wood duck, whistling ducks, sea ducks, the ruddy duck, and mergansers) (Clapp et al., 1982; National Geographic Society, 1983; Madge and Burn, 1988). Many species usually migrate from wintering grounds along the Gulf Coast to summer nesting grounds in the north. Waterfowl migration pathways have traditionally been divided into four parallel north-south paths, or "flyways," across the North American continent. The Gulf of Mexico coast serves as the southern terminus of both Central (Texas) and Mississippi (Louisiana, Mississippi, and Alabama) flyways. Waterfowl are highly social and possess a diverse array of feeding adaptations related to their habitat (Johnsgard, 1975).

3.2.7.2. Endangered and Threatened Species

The following coastal and marine bird species that inhabit or frequent the north-central and western Gulf of Mexico coastal areas are recognized by FWS as either endangered or threatened: piping plover, whooping crane, bald eagle, brown pelican, and least tern.

Piping Plover

The piping plover (*Charadrius melodus*) is a migratory shorebird that is endemic to North America. The piping plover breeds on the northern Great Plains, in the Great Lakes, and along the Atlantic Coast (Newfoundland to North Carolina); and winters on the Atlantic and Gulf of Mexico coasts from North Carolina to Mexico and in the Bahamas West Indies. The final rule on critical habitat of piping plover was published July 10, 2001; there are 20 units of critical habitat in western Florida south to Tampa Bay, 3 areas in Alabama, 15 in Mississippi, 7 in Louisiana, and 37 in Texas (66 FR 132, pp. 36037-36086). Critical wintering habitat includes the land between mean lower low water and any densely vegetated habitat, which is not used by the piping plover. It has been hypothesized that specific wintering habitat, which includes coastal sand flats and mud flats in close proximity to large inlets or passes, may attract the largest concentrations of piping plovers because of a preferred prey base and/or because the substrate coloration provides protection from aerial predators due to chromatic matching, or camouflage (Nicholls and Baldassarre, 1990). This species remains in a precarious state given its low population numbers, sparse distribution, and continued threats to habitat throughout its range. Of the birds located on the U.S. wintering grounds during censuses of 1991 and 1996, about 89 percent were found on the Gulf Coast and 8 percent on the Atlantic Coast. Along the Gulf Coast, the highest numbers of wintering plovers occur along the Texas coast (1,333) (Haig and Plissner, 1993). Piping plovers begin arriving on the wintering grounds in July and keep arriving through September. Behavioral observations of piping plovers on the wintering grounds suggest that they spend the majority of their time foraging. Primary prey for wintering plovers includes polychaete marine worms, various crustaceans, insects, and sometimes bivalve mollusks. They peck prey from on top of or just beneath the sediment. Foraging usually is on moist or wet sand, mud, or fine shell. In some cases, a mat of blue-green algae may cover this substrate. When not foraging, plovers can be found in aggressive encounters, roosting, preening, bathing, and moving among available habitat locations. The habitats used by wintering birds include beaches, mud flats, sand flats, algal flats, and washover passes (areas where breaks in the sand dunes result in an inlet). Wintering plovers are dependent on a mosaic of habitat patches and move among these patches depending on local weather and tidal conditions. In late February, piping plovers begin leaving the wintering grounds to migrate back to their breeding sites. Northward migration peaks in late March, and by late May most birds have left the wintering grounds. The migration of the piping plover is poorly understood.

Whooping Crane

The whooping crane (*Grus americana*) is an omnivorous, wading bird. The whooping crane formerly ranged from summer breeding grounds within the central Canadian provinces and northern prairie states to southern coastal wintering grounds from central Mexico to the Carolinas (Bent, 1926). Whooping cranes currently exist in three wild populations and at five captive locations (USDOI, FWS, 1994). The only self-sustaining wild population nests in the Northwest Territories and adjacent areas of Alberta, Canada, primarily within the boundaries of Wood Buffalo National Park (WBNP). These birds winter in coastal marshes and estuarine habitats along the Gulf of Mexico coast at Aransas National Wildlife Refuge (ANWR), Texas, and represent the majority of the world's population of free-ranging whooping cranes. Another wild flock was created with the transfer of wild whooping crane eggs from nests in the WBNP to be reared by wild sandhill cranes in an effort to establish a migratory, Rocky Mountains Population (USDOI, FWS, 1994). This population summers in Idaho, western Wyoming, and southwestern Montana and winter in the middle Rio Grande Valley, New Mexico. The third wild population is the first step in an effort to establish a nonmigratory population in Florida (USDOI, FWS, 1994). The December 1993 wild population was estimated at 160; the captive population contained 101 birds (USDOI, FWS, 1994).

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is the only species of sea eagle that regularly occurs on the North American continent (USDOI, FWS, 1984). Its range extends from central Alaska and Canada to northern Mexico. The bulk of the bald eagle's diet is fish, though bald eagles will opportunistically take birds, reptiles, and mammals (USDOI, FWS, 1984). The historical nesting range of the bald eagle within the Southeast United States included the entire coastal plain and shores of major rivers and lakes. The current range is limited, with most breeding pairs occurring in Florida and Louisiana, and some in South Carolina, Alabama, and east Texas. One hundred twenty nests have been found in Louisiana; only 3 nests occurred within 5 mi of the coast (Patrick, written communication, 1997). The bald eagle was listed as endangered in 1967 in response to the declines due to DDT and other organochlorines that affected the species' reproduction (USDOI, FWS, 1984). Recovery may be slowed by human disturbance if it affects the abundance of preferable trees for nesting and perching. Preferred perch trees may be relatively large in diameter, height, surrounding percent forest cover, surrounding size of block of forest, height of surrounding canopy above the ground, height of perch above surrounding canopy, and size of the angle of open flight path to the perch (Buehler et al., 1992; Chandler et. al., 1995). For preferred nest trees, important features may be proximity to water (usually within 1/2 mile), a clear flight path to a close point on the water, an open view of the surrounding area and proximity to preferable perch trees. In July 1995, the FWS reclassified the bald eagle from endangered to threatened in the lower 48 states (*Federal Register*, 1995b).

Brown Pelican

The brown pelican (*Pelicanus occidentalis*) is one of two pelican species in North America. It feeds entirely upon fishes captured by plunge diving in coastal waters. Organochlorine pesticide pollution apparently contributed to the endangerment of the brown pelican. Organochlorines like DDT accumulate up the food web and reach their highest concentrations in predators such as the brown pelican. The pesticides interfere with calcium metabolism, causing reduced calcification of egg shells, and potentially allowing the eggs to be crushed under the weight of an incubating parent. In recent years, there has been a marked increase in brown pelican populations within the former range of the species. The population of brown pelicans and their habitat in Alabama, Florida, Georgia, North and South Carolina, and points northward along the Atlantic Coast were removed from the endangered species list in 1985; however, within the remainder of the range, which includes coastal areas of Texas, Louisiana, and Mississippi, where populations are not secure, the brown pelican remains listed as endangered (*Federal Register*, 1985b). Ten thousand nests and an estimated 25,000 adults were found in Louisiana (Patrick, written communication, 1997). The Louisiana Department of Wildlife and Fisheries submitted a request in March 1994 to the FWS to officially remove the eastern brown pelican from the endangered species list in Louisiana (Louisiana Dept. of Wildlife and Fisheries, 1994).

Least Tern

The least tern (*Sterna antillarum*) is the smallest North American tern. Three subspecies of New World least terns were recognized by the American Ornithologists' Union (1957). These are the interior least tern (*Sterna antillarum athalossus*), the eastern or coastal least tern (*S. antillarum antillarum*), and the California least tern (*S. antillarum browni*). According to *Federal Register* (1985b), "Because of the taxonomic uncertainty of least tern subspecies in eastern North America, the [Fish and Wildlife] Service decides not to specify the subspecies in this final rule. Instead the Service designates as endangered the population of least terns (hereinafter referred to as interior least tern) occurring in the interior of the United States." Least terns within 50 mi of the Gulf Coast are not are listed as endangered and will not be further analyzed here.

3.2.8. Gulf Sturgeon

The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) is the only listed threatened fish species in the Gulf of Mexico. In 1991, the Gulf sturgeon was listed as threatened. Subsequently, a recovery plan was developed to ensure the preservation and protection of Gulf sturgeon spawning habitat (USDOI, FWS, and Gulf States Marine Fisheries Commission, 1995). The decline of the Gulf sturgeon is believed to be due to overfishing and habitat destruction, primarily the damming of coastal rivers and the degradation of water quality (Barkuloo, 1988).

A subspecies of the Atlantic sturgeon, the Gulf sturgeon is anadromous, with immature and mature fish participating in freshwater migrations. Gill netting and biotelemetry have shown that subadults and adults spend 8-9 months each year in rivers and 3-4 of the coolest months in estuaries or Gulf waters. Sturgeon less than about two years old remain in riverine habitats and estuaries throughout the year (Clugston, 1991). According to Wooley and Crateau (1985), the present range of the Gulf sturgeon is probably from the Suwanee River in west-central Florida to eastern Louisiana. Extant occurrences of the fish have been reported near Galveston Island in southeast Texas (one specimen) east to Charlotte Harbor in southwest Florida (5 fish) (USDOI, FWS and Gulf States Marine Fisheries Commission, 1995). Gulf sturgeon population sizes are largely unknown throughout the species' range, but estimates have been completed recently for the Suwannee, Apalachicola, and West Pearl Rivers, and the first year of a 3-year study has been completed on the Choctawhatchee River. Surveys have not been conducted yet on the remaining river systems that historically contained Gulf sturgeon. Gulf sturgeon historically spawned in major rivers of Alabama, Mississippi, and the Florida northern Gulf Coast. Until recently only two spawning sites were known, both in the Suwannee River in Florida. Eggs have now been discovered in six locations within the Choctawhatchee River system in Florida and Alabama (Fox and Hightower, 1998). In spring, large subadults and adults that migrate from the estuaries or the Gulf into major river passes feed primarily on lancelets, brachiopods, amphipods, polychaetes, and globular molluscs. Small sturgeon that remain in river passes during spring feed on amphipods, shrimp, isopods, oligochaetes, and aquatic insect larvae (Clugston, 1991). During the riverine stage, adults cease feeding, undergo gonadal maturation, and migrate upstream to spawn. Spawning occurs in freshwater reaches of the river, over coarse substrate in deep areas or holes with hard bottoms and where some current is present (Sulak and Clugston, 1998; Fox et al., 2000). Females lay large numbers of eggs. A large female was reported to have the capability of producing of 275,000-475,000 eggs (Chapman at al., 1993). These eggs are adhesive and will attach to rocks, vegetation, or other objects. They hatch in about 1 week depending upon the temperature of the water.

Fisheries scientists interrupt migrating Gulf sturgeon in the rivers and estuaries by capture with nets suspended from floats in the rivers and river mouths. Gill nets with mesh wide enough not to close the very large opercula are used. No capture or tracking is feasible in the open Gulf just when the fish migrate into it because cold fronts come every 2-3 days, with up to 9-ft seas. Conditions are dangerous for the size of vessel required, and the paths traveled in the open Gulf cannot be followed beyond the estuaries. Thus, the offshore winter distribution of Gulf sturgeon relative to the location of the activities under the proposed action is unknown. However, there have been no reported catches of this species in Federal waters (Sulak, personal communication, 1997).

Tagging studies suggest that Gulf sturgeon exhibit a high degree of river fidelity. Stabile et al. (1996) analyzed Gulf sturgeon populations from eight drainages along the Gulf of Mexico for genetic diversity. He noted significant differences among Gulf sturgeon stocks and suggested that they displayed region-specific affinities and may exhibit river-specific fidelity. Stabile et al. (1996) identified five regional or river-specific stocks (from west to east): (1) Lake Pontchartrain and Pearl River, (2) Pascagoula River, (3) Escambia and Yellow Rivers, (4) Choctawhatchee River, and (5) Apalachicola, Ochlockonee, and Suwannee Rivers.

Sturgeon are bottom suction feeders that have ventrally located, highly extrusible mouths. The sturgeon head is dorsoventrally compressed with eyes dorsal so benthic food under the sturgeon's mouth will not be visible. However, they have taste barbels, like catfish, to detect prey. The barbels are also useful for feeding in high-order streams when they are muddy. However, Gulf sturgeon are common in clear water streams also. The barbels may locate food at night when visibility of prey is low from any direction. Fishes that forage by taste are opportunistic feeders because smell is much more discriminating than taste. Another adaptation of sturgeon to mainstem rivers and offshore waters is mobility (an adaptation to the large habitat scale). High fecundity (egg number) facilitates wide dispersal, a major adaptation to the high variance of habitat quality resulting from diverse habitats and dynamic nature of mainstems of watersheds. A major threat to sturgeon populations in various species worldwide is damming of the mainstem rivers.

3.2.9. Fisheries

3.2.9.1. Fish Resources

Ichthyoplankton

Most fishes inhabiting the Gulf of Mexico, whether benthic or pelagic as adults, have pelagic larval stages. For various lengths of time (10-100 days depending on the species), these pelagic eggs and larvae become part of the planktonic community. Variability in survival and transport of pelagic larval stages is thought to be an important determinant of future year-class strength in adult populations of fishes and invertebrates (Underwood and Fairweather, 1989; Doherty and Fowler, 1994). For this reason, larval fishes and the physical and biological factors that influence their distribution and abundance have received increasing attention from marine ecologists. In general, the distribution of fish larvae depends on spawning behavior of adults, hydrographic structure and transport at a variety of scales, duration of the pelagic period, behavior of larvae, and larval mortality and growth (Leis, 1991).

Ichthyoplankton sampling at a regional scale in the Gulf of Mexico began in the early 1970’s with routine surveys for king and Spanish mackerel larvae (Wollam, 1970; Dwinell and Futch, 1973). Houde et al. (1979) conducted major surveys of ichthyoplankton in the Eastern Gulf of Mexico from 1972 to 1974. They sampled 483 stations located on a grid extending from 24º 30′ N. latitude to 29º 30′ N. latitude and from depths of 10-200 m (33-656 ft). Finucane et al. (1977) collected eggs and ichthyoplankton from areas off the Texas continental shelf over a three-year period (1975-1977) as part of the South Texas Outer Continental Shelf Studies. They sampled between Port Isabel and Matagorda Bay, Texas, covering an area of approximately 100 by 300 km. In 1977, the first comprehensive surveys of the Southeastern Area Monitoring and Assessment Program (SEAMAP) began collecting larval fishes in the Gulf of Mexico from a grid of sampling stations encompassing the entire northern Gulf of Mexico (Sherman et al., 1983; Richards et al., 1984; Kelley et al., 1986). More recently, larval fish researchers have been sampling well-defined hydrographic features such as the Mississippi River discharge plume (Govoni et al., 1989; Grimes and Finucane, 1991) and the Loop Current frontal boundary (Richards et al., 1989 and 1993). These studies have used real-time physical oceanographic data to guide sampling near the hydrographic features of interest. For the aforementioned surveys, most investigators sampled ichthyoplankton using towed bongo (water column) and neuston (sea surface) nets and occasionally discrete depth nets, with mesh sizes ranging from 0.333 to 1.00 mm (Ditty et al., 1988). Taxonomic resolution in most published studies is at the family level.

Richards (1990) estimates that there are 200 families with more than 1,700 species whose early life stages may occur in the Gulf of Mexico. In addition to the resident fauna, many eggs, larvae, and juveniles may be advected into the Gulf from the Caribbean Sea via the Loop Current. In their study of the Loop Current front, Richards et al. (1993) identified 237 taxa representing 100 families. They considered this a remarkable family-level diversity when compared with previous surveys made in the Gulf of Mexico and other oceans. The diversity was attributed to a mix of fauna from tropical and warm temperate oceanic, mesopelagic, and coastal demersal and pelagic species. The larval sampling surveys by Houde et al. (1979) yielded over 200 taxa from 91 families in the Eastern Gulf of Mexico. Ditty et al. (1988) summarized information from over 80 ichthyoplankton studies from the northern Gulf of Mexico (north of 26º N) and reported 200 coastal and oceanic fishes from 61 families. Preliminary SEAMAP cruises collected 137 genera and species from 91 families (Sherman et al., 1983). The most abundant families collected in the Eastern Gulf by Houde et al. (1979) were clupeids (herrings), gobiids (gobies), bregmacerotids (codlets), carangids (jacks), synodontids (lizardfishes), myctophids (lanternfishes), serranids (seabasses), ophidiids (cusk eels), and labrids (wrasses). These families contributed 64 percent of the total taxa collected by Houde et al. (1979). Finucane et al. (1977) reported the most dominant taxa from their south Texas collections occurred in the myctophids (lanternfishes) followed by the sciaenids (drums) and scombrids (mackerels and tunas). Sherman et al. (1983) compared the rank order of the 21 most abundant families overall and by quadrant (northeast, northwest, southeast, southwest) taken during early SEAMAP cruises (Table 3-6).

Species such as Atlantic croaker, spot, and Gulf menhaden migrate to the outer shelf during winter months to spawn. Consequently, larvae of these species are often numerically dominant during winter months. Many families have numerous species within them, such as engraulids, searobins (Triglidae), tonguefishes (Cygnoglossidae), and pufferfishes (Tetradontiidae). Species from these families were collected during all months.

Many taxa were only collected over waters within certain depth ranges (Table 3-7). Species found exclusively in water depths shallower than 25 m (82 ft) were mostly inshore demersal species such as Atlantic bumper (*Caranx ruber*), spotted seatrout (*Cynoscion nebulosus*), pigfish (*Orthopristis chrysoptera*), and black drum (*Pogonias cromis*). At depths >100 m (>328 ft), several clupeids (*Brevoortia patronus*, *Opisthonema oglinum*, and *Sardinella aurita*), several serranids (*Centropristis striata*, *Diplectrum formosum*, and *Serraniculus pumilio*), Atlantic croaker (*Micropogon undulatus*), and spot (*Bairdiella chrysura*) were most common in collections. Two tunas (*Auxis* sp. and *Euthynnus alletteratus*), blue runner (*Caranx crysos*), round herring (*Etrumeus teres*), red barbier (*Hemanthias vivanus*), red snapper (*Lujanus campechanus*), king mackerel (*Scomberomorus cavalla*), and rough scad (*Trachurus lathami*) were collected only over water depths of 50-200 m (164-656 ft). Wide-ranging epipelagic species such as skipjack tuna (*Euthynnus pelamis*), sailfish (*Istiophorus platypterus*), and Atlantic swordfish (*Xiphias gladius*) were collected only in water depths exceeding 150 m (492 ft).

Two of the most important hydrographic features in the Gulf of Mexico are the Mississippi River discharge plume and the Loop Current. A series of investigations have shown that ichthyoplankton aggregate at the frontal zone of the Mississippi River discharge plume (Govoni et al., 1989; Grimes and Finucane, 1991; Govoni and Grimes, 1992). Grimes and Finucane (1991) sampled larval fishes, chlorophyll *a*, and zooplankton along transects traversing the discharge plume. Total ichthyoplankton catch per tow, individual surface chlorophyll *a* values, and zooplankton volumes were all considerably greater in frontal waters than adjacent shelf or plume waters. They found that when comparing catches of ichthyoplankton among shelf, frontal, and plume samples that frontal samples contained a higher average number of fish larvae than either plume or shelf waters. Hydrodynamic convergence and the continually reforming turbidity fronts associated with the discharge plume probably accounted for the concentration of larval fishes at the front. These investigators hypothesized that frontal waters provide feeding and growth opportunities for larvae. Bothids, carangids, engraulids, exocoetids, gobiids, sciaenids, scombrids, synodontids, and tetraodontids were the nine most frequently caught taxa in the plume/shelf samples off the Mississippi River Delta (Grimes and Finucane, 1991).

Richards et al. (1989 and 1993) examined the distribution of larval fishes along eight transects across the Loop Current boundary, as defined from satellite imagery of sea surface temperature. Most of the samples were off the continental shelf in water depths exceeding 200 m (656 ft). Although 100 fish families were identified, only 25 families were represented by >0.5 individuals/sample. Of these, the lanternfishes were most abundant. A cluster analysis of the 25 most-abundant families resolved three assemblages: oceanic, shelf, and frontal. The oceanic assemblage consisted of mesopelagic families such as hachetfishes (sternoptichyids), lanternfishes (myctophids), and bristlemouths (gonostomatids). The shelf group was subdivided into three groups including demersal taxa (e.g., sciaenids and bothids), coastal pelagic taxa (e.g., carangids and scombrids), and widely dispersing reef species (e.g., labrids, scarids, and scorpaenids). The frontal group consisted of both oceanic and shelf taxa. These studies suggest that water temperature is a major influence on the structure of larval fish assemblages (Richards et al., 1993).

All of the studies previously mentioned were conducted in the open Gulf of Mexico in shelf or oceanic waters. One survey by Ruple (1984) concentrated on the surf zone ichthyoplankton along a barrier island beach offshore Mississippi. Over the course of a year, Ruple (1984) sampled inner and outer surf zone regions and collected almost 40,000 larval fishes represented by 69 taxa. The most abundant taxa collected from the outer surf zone were anchovies (Engraulidae), Atlantic bumper, and tonguefishes. From the inner surf zone, engraulids, spot, Gulf menhaden, and hogchoker were most abundant. Seasonal peaks in abundance occurred at the outer surf zone stations during May and June and at the inner surf zone stations during December. The importance of the surf zone as habitat for larval fishes was not clear, but it appeared as though many of the larvae collected were large in size and may have been intercepted during their shoreward migration into Mississippi Sound where they would normally take up residence as benthic juveniles.

Larval fishes are highly dependent on zooplankton until they can feed on larger prey. In the northern Gulf of Mexico, the diets of Atlantic croaker, Gulf menhaden, and spot consist mainly of copepods and copepod nauplii, larval bivalves, pteropods, and the dinoflagellate *Prorocentrum* sp. (Govoni et al., 1989).

Fishes

Finfish

The Gulf of Mexico supports a great diversity of fish resources that are related to variable ecological factors, including salinity, primary productivity, and bottom type. These factors differ widely across the Gulf of Mexico and between the inshore and offshore waters. Characteristic fish resources are associated with the various environments and are not randomly distributed. High densities of fish resources are associated with particular habitat types. Most finfish resources are linked both directly and indirectly to the vast estuaries that ring the Gulf of Mexico. Finfish are directly estuary dependent when the population relies on low-salinity brackish wetlands for most of their life history, such as during the maturation and development of larvae and juveniles. Even the offshore demersal species are indirectly related to the estuaries because they influence the productivity and food availability on the continental shelf (Darnell and Soniat, 1979; Darnell, 1988). Approximately 46 percent of the southeastern United States wetlands and estuaries important to fish resources are located within the Gulf of Mexico (Mager and Ruebsamen, 1988). Consequently, estuary-dependent species of finfish and shellfish dominate the fisheries of the central and north-central Gulf.

The life history of estuary-dependent species involves spawning on the continental shelf; transporting eggs, larvae, or juveniles to the estuarine nursery grounds; growing and maturing in the estuary; and migrating of the young adults back to the shelf for spawning. After spawning, the adult individuals generally remain on the continental shelf. Movement of adult estuary-dependent species is essentially onshore-offshore with no extensive east-west or west-east migration.

Estuary-related species of commericial importance include menhaden, shrimps, oyster, crabs, and sciaenids. Estuary communities are found from east Texas through Louisiana, Mississippi, Alabama, and northwestern Florida. Darnell et al. (1983) and Darnell and Kleypas (1987) found that the density distribution of fish resources in the Gulf was highest nearshore off the central coast. For all seasons, the greatest abundance occurred between Galveston Bay and the Mississippi River. The abundance of fish resources in the far Western and Eastern Gulf of Mexico is patchy. The high-salinity bays of the Western Gulf contain no distinctive species, only a greatly reduced component of the general estuary community found in lower salinities (Darnell et al., 1983).

Estuaries and rivers of the Gulf of Mexico export considerable quantities of organic material, thereby enriching the adjacent continental shelf areas (Grimes and Finucane, 1991; Darnell and Soniat, 1979). Populations from the inshore shelf zone (7-14 m) are dominated seasonally by Atlantic croaker, spot, drum, silver seatrout, southern kingfish, and Atlantic threadfin. Populations from the middle shelf zone (27-46 m) include sciaenids but are dominated by longspine porgies. The blackfin searobin, Mexican searobin, and shoal flounder are dominant on the outer shelf zone (64-110 m).

The degradation of inshore water quality and loss of Gulf wetlands as nursery areas are considered significant threats to fish resources in the Gulf of Mexico (Christmas et al., 1988; Horst, 1992a). Loss of wetland nursery areas in the north-central Gulf is believed to be the result of channelization, river control, and subsidence of wetlands (Turner and Cahoon, 1988). Loss of wetland nursery areas in the far Western and Eastern Gulf is believed to be the result of urbanization and poor water management practices (USEPA, 1989a).

Gulf menhaden and members of the Sciaenidae family such as croaker, red and black drum, and spotted sea trout are directly dependent on estuaries during various phases of their life history. The occurrence of dense schools, generally by members of fairly uniform size, is an outstanding characteristic that facilitates mass production methods of harvesting menhaden. The seasonal appearance of large schools of menhaden in the inshore Gulf waters from April to November dictates the menhaden fishery (Nelson and Ahrenholz, 1986). Larval menhaden feed on pelagic zooplankton in marine and estuarine waters. Juvenile and adult Gulf menhaden become filter-feeding omnivores that primarily consume phytoplankton, but also ingest zooplankton, detritus, and bacteria. As filter-feeders, menhaden form a basal link in estuarine and marine food webs and, in turn, are prey for many species of larger fish (Vaughan et al., 1988).

Sciaenids are opportunistic carnivores whose food habits change with size. Larval sciaenids feed selectively on pelagic zooplankton, especially copepods. Juveniles feed upon invertebrates, changing to a primarily fish diet as they mature (Perret et al., 1980; Sutter and McIlwain, 1987; USDOC, NOAA, 1986).

Reeffish species occur in close association with natural or manmade materials on the seafloor. Live-bottom areas of low or high vertical relief partition reefal areas from surrounding sand/shell hash/mud bottom. A number of important reeffish species share the common life history characteristics of offshore spawning and transport of larvae inshore to settle in estuaries and seagrass meadows where they spend an obligatory nursery phase before recruiting to adult stocks offshore. Among these fishes are both winter and summer spawners, with gag (*Mycteroperca micolepis*) and grey snapper (*Lutjanus griseus*), respectively, being good examples. Gag have become a particularly significant species in the Eastern Gulf where spawning aggregations have been studied over a significant period. Gag spawn in February and March in a defined area west of the Florida Middle Ground, and larvae are transported inshore to settle in seagrass meadows 30-50 days later. Two new reserves have been designated (described in Chapter 3.3.1) in this area where fishing activities have been prohibited. Juveniles remain in the seagrass nursery areas until October or November when they recruit to adult stocks offshore.

Other reeffish species are considered nonestuary dependent such as the red snapper, which remain close to underwater structure. Red snapper feed along the bottom on fishes and benthic organisms such as crustaceans and mollusks. Juveniles feed on zooplankton, small fish, crustaceans, and mollusks (Bortone and Williams, 1986; USDOC, NOAA, 1986).

Many of the commercially important fish species in the Gulf of Mexico are believed to be in decline due to overfishing (USDOC, NMFS, 2001a). Continued fishing at the present levels is likely to result in eventual failure of certain fisheries. Competition between large numbers of fishermen, between fishing operations employing different methods, and between commercial and recreational fishermen for a given resource may reduce standing populations. Fishing techniques such as trawling, gill netting, or purse seining, when practiced nonselectively, may reduce the standing stocks of the desired target species as well as substantially affect fish resources other than the target. Standing stocks of some traditional fisheries, such as shrimp, shark, and tuna, have declined in the past and have required additional management restrictions resulting in some successes (Goodyear and Phares, 1990; USDOC, NMFS, 1999a; Rothschild et al., 1997; Schirripa and Legault, 1997). Recruitment is by far the most important, yet the least understood, factor contributing to changes in the numbers of harvestable Gulf fish. Natural phenomena such as weather, hypoxia, and red tides may reduce standing populations. Finally, hurricanes may affect fish resources by destroying oyster reefs and changing physical characteristics of inshore and offshore ecosystems (Horst, 1992a).

Shellfish

To a greater degree, estuaries determine the shellfish resources of the Gulf of Mexico. Life history strategies are influenced by tides, lunar cycles, maturation state, and estuarine temperature changes. Very few individuals live more than a year, and most are less than six months old when they enter the extensive inshore and nearshore fishery. Year-to-year variations in shellfish populations are frequently as high as 100 percent and are most often a result of extremes in salinity and temperature during the period of larval development. Shellfish resources in the Gulf range from those located only in brackish wetlands to those found mainly in saline marsh and inshore coastal areas. Life history strategies reflect estuary relationships, ranging from total dependence on primary productivity to opportunistic dependence on benthic organisms. Gulf shellfish resources are an important link in the estuary food chain between benthic and pelagic organisms (Darnell et al., 1983; Darnell and Kleypas, 1987; Turner and Brody, 1983).

Up to 15 species of penaeid shrimp can be expected to use the coastal and estuarine areas in the Gulf of Mexico. Brown, white, and pink shrimp are the most numerous. Pink shrimp have an almost continuous distribution throughout the Gulf but are most numerous on the shell, coral sand, and coral silt bottoms off southern Florida. Brown and white shrimp occur in both marine and estuarine habitats. Adult shrimp spawn offshore in high salinity waters; the fertilized eggs become free-swimming larvae. After several molts they enter estuarine waters as postlarvae. Wetlands within the estuary offer both a concentrated food source and a refuge from predators. After growing into juveniles the shrimp larvae leave the saline marsh to move offshore where they become adults. The timing of immigration and emigration, spatial use of a food-rich habitat, and physiological and evolutionary adaptations to tides, temperature, and salinity differ between the two species (Muncy, 1984; Turner and Brody, 1983; USDOC, NOAA, 1986).

About eight species of portunid (swimming) crabs use the coastal and estuarine areas in the Gulf of Mexico. Blue crabs (*Callinectes sapidus*) are the only species, however, that is located throughout the Gulf and comprises a substantial fishery. They occur on a variety of bottom types in fresh, estuarine and shallow offshore waters. Spawning grounds are areas of high salinity such as saline marshes and nearshore waters.

Vast intertidal reefs constructed by sedentary oysters are prominent biologically and physically in estuaries of the Gulf of Mexico. Finfishes, crabs, and shrimp are among the animals using the intertidal oyster reefs for refuge and also as a source of food, foraging on the many reef-dwelling species. Reefs, as they become established, modify tidal currents and this, in turn, affects sedimentary patterns. Further, the reefs contribute to the stability of bordering marsh (Kilgen and Dugas, 1989). Additional information on shellfish and their life histories can be found in GMFMC (1998).

Pelagics

Pelagic fishes occur throughout the water column from the beach to the open ocean. Water-column structure (temperature, salinity, and turbidity) is the only partitioning of this vast habitat. On a broad scale, pelagic fishes recognize different watermasses based upon physical and biological characteristics. Three ecological groups, delineated by watermass, will be discussed individually:

- coastal pelagic species;
- oceanic pelagic species; and
- mesopelagic species.

Coastal pelagic species occur in waters from the shoreline to the shelf edge. Oceanic species occur mainly in oceanic waters offshore from the shelf break; however, some species venture onto the shelf with watermass (e.g., Loop Current) intrusions. Mesopelagic fishes occur below the oceanic species group in the open ocean, usually at depths of 200-1,000 m (656-1,280 ft) depending upon absolute water depth.

For coastal pelagic fishes, commercial fishery landings are one of the best sources of information because these species are an important component of nearshore net and hook-and-line fisheries. Some smaller nektonic fishes occupying the surf zone along exposed beaches have been collected with seines (Naughton and Saloman, 1978; Ross, 1983). Information on the distribution and abundance of oceanic species comes from commercial longline catches and recreational fishing surveys. In addition, NMFS has conducted routine surveys of the Gulf of Mexico billfishery since 1970 (Pristas et al., 1992). Mesopelagic species are not harvested commercially but have been collected in special, discrete-depth nets that provide some quantitative data on relative abundance (Bakus et al., 1977; Hopkins and Lancraft, 1984; Hopkins and Baird, 1985; Gartner et al., 1987).

Recently, additional restrictions have been placed on the harvest of some sharks. Effective July 1, 2000, it is prohibited to retain, possess, sell, or purchase the following sharks: white, basking, sand tiger, bigeye sand tiger, dusky, bignose, Galapagos, night, Caribbean reef, narrowtooth, Caribbean sharpnose, smalltail, Atlantic angel, longfin, mako, bigeye thresher, sevengill, sixgill, and bigeye sixgill.

Coastal Pelagics

The major coastal pelagic families occurring in the region are Carcarhinidae (requiem sharks), Elopidae (ladyfish), Engraulidae (anchovies), Clupeidae (herrings), Scombridae (mackerels and tunas), Carangidae (jacks and scads), Mugilidae (mullets), Pomatomidae (bluefish), and Rachycentridae (cobia). Coastal pelagic species traverse shelf waters of the region throughout the year. Some species form large schools (e.g., Spanish mackerel), while others travel singly or in smaller groups (e.g., cobia). The distribution of most species depends upon water-column structure, which varies spatially and seasonally.

Some coastal pelagic species show an affinity for vertical structure and are often observed around natural or artificial structures, where they are best classified as transients rather than true residents. This is particularly true for Spanish sardine, round scad, blue runner, king mackerel, and cobia (Klima and Wickham, 1971; Chandler et al., 1985).

Some coastal pelagic species are found along high-energy sandy beaches from the shoreline to the swash zone (Ross, 1983). An estimated 44-76 species, many of them coastal pelagics, occur in the surf zone assemblage. Surveys have shown a high degree of dominance, with 4-10 species accounting for 90 percent of the numbers collected. In the northern Gulf of Mexico, pelagic species such as scaled sardine, Florida pompano, and various anchovies are among the numerically dominant species in seine collections (Ross, 1983). Surf zone fish assemblages show considerable seasonal structuring in the northern Gulf of Mexico (Naughton and Saloman, 1978; Ross and Modde, 1981). The lowest abundance of all species occurs in winter, with peak numbers found during summer and fall. Larger predatory species (particularly bluefish, Spanish mackerel, and blue runner) may be attracted to large concentrations of anchovies, herrings, and silversides that congregate in the surf zone.

Coastal pelagic fishes can be divided into two ecological groups. The first group includes larger predatory species such as king and Spanish mackerel, bluefish, cobia, jacks, and little tunny. These species typically form schools, undergo migrations, grow rapidly, mature early, and exhibit high fecundity. The second group exhibits similar life history characteristics, but the species are smaller in body size and are planktivorous. This group is composed of Gulf menhaden, thread herring, Spanish sardine, round scad, and anchovies. Species in the second group are preyed upon by the larger species in the first group; thus, the two are ecologically important in energy transfer in the nearshore environment (Saloman and Naughton, 1983 and 1984).

Commercial purse seine fisheries generate high landings of several coastal pelagic species in the region. The Gulf menhaden fishery produces the highest fishery landings in the U.S. (USDOC, NMFS, 2001b). Menhaden form large, surface-feeding schools in waters near the Mississippi Delta from April through September. Fishermen take advantage of this schooling behavior, capturing millions of pounds each year with large purse nets. Other coastal pelagic species contributing high commercial landings are round scad and ladyfish.

Most of the large-bodied, predatory coastal pelagic species are important to commercial or recreational fisheries. King and Spanish mackerel, cobia, and jacks are sought by the charter and head-boat fisheries in the region. King mackerel occurring in the shelf waters of the region may actually come from two distinct populations (Johnson et al., 1994). The eastern population migrates from near the Mississippi Delta eastward, then southward around the Florida peninsula, wintering off southeastern Florida (Sutter et al., 1991). The western population travels to waters off the Yucatan Peninsula during winter. In summer, both populations migrate to the northern Gulf of Mexico, where they intermix to an unknown extent (Johnson et al., 1994). Spanish mackerel, cobia, bluefish, jack crevalle, and coastal sharks are migratory, but their routes have not been studied.

Oceanic Pelagics

Common oceanic pelagic species include tunas, marlins, sailfish, swordfish, dolphins, wahoo, and mako sharks. In addition to these large predatory species, there are halfbeaks, flyingfishes, and driftfishes (Stromateidae). Lesser-known oceanic pelagics include opah, snake mackerels (Gempylidae), ribbonfishes (Trachipteridae), and escolar.

Oceanic pelagic species occur throughout the Gulf of Mexico, especially at or beyond the shelf edge. Oceanic pelagics are reportedly associated with mesoscale hydrographic features such as fronts, eddies, and discontinuities. Fishermen contend that yellowfin tuna aggregate near sea-surface temperature boundaries or frontal zones; however, Power and May (1991) found no correlation between longline catches of yellowfin tuna and sea-surface temperature (defined from satellite imagery) in the Gulf of Mexico. The occurrence of bluefin tuna larvae in the Gulf of Mexico associated with the Loop Current boundary and the Mississippi River discharge plume is evidence that these species spawn in the Gulf of Mexico (Richards et al., 1989). Many of the oceanic fishes associate with drifting *Sargassum*, which provides forage areas and/or nursery refugia.

Mesopelagics

Mesopelagic fish assemblages in the Gulf of Mexico are numerically dominated by myctophids (lanternfishes), with gonostomatids (bristlemouths) and sternoptychids (hachetfishes) common but less abundant in collections. These fishes make extensive vertical migrations during the night from mesopelagic depths (200-1,000 m or 656-3,280 ft) to feed in higher, food rich layers of the water column (Hopkins and Baird, 1985). Mesopelagic fishes are important ecologically because they transfer substantial amounts of energy between mesopelagic and epipelagic zones over each diel cycle.

Hopkins and Lancraft (1984) collected 143 mesopelagic fishes from the Eastern Gulf of Mexico during 12 cruises from 1970 to 1977. Most of their collections were made near 27º N, 86º W. Lanternfishes were most common in the catches made by Bakus et al. (1977) and Hopkins and Lancraft (1984). Bakus et al. (1977) analyzed lanternfish distribution in the western Atlantic Ocean and recognized the Gulf of Mexico as a distinct zoogeographic province. Species with tropical and subtropical affinities were most prevalent in the Gulf of Mexico lanternfish assemblage. This was particularly true for the Eastern Gulf, where Loop Current effects on species distribution were most pronounced. Gartner et al. (1987) collected 17 genera and 49 species of lanternfish in trawls fished at discrete depths from stations in the South, Central, and Eastern Gulf. The most abundant species in decreasing order of importance were *Ceratoscopleus warmingii*, *Notolychus valdiviae*, *Lepidophanes guentheri*, *Lampanyctus alatus*, *Diaphus dumerili*, *Benthosema suborbitale*, and *Myctophum affine*. Ichthyoplankton collections from oceanic waters yielded high numbers of mesopelagic larvae as compared with larvae of other species (Richards et al., 1989). Lanternfishes generally spawn year-round, with peak activity in spring and summer (Gartner, 1993).

3.2.9.2. Essential Fish Habitat

The Essential Fish Habitat Program in the Gulf of Mexico

As outlined in Chapter 1.3, the Magnuson Fishery Conservation and Management Act of 1976, as amended through 1998, places new requirements on any Federal agency regarding essential fish habitat (EFH). The MMS must now describe how actions under their jurisdiction may affect EFH. All Federal agencies are encouraged to include EFH information and assessments within NEPA documents.

An EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, and growth to maturity. Because of the wide variation of habitat requirements for all life history stages (as described above), EFH for the Gulf of Mexico includes all estuarine and marine waters and substrates from the shoreline to the seaward limit of the U.S. Exclusive Economic Zone (EEZ).

The NOAA Fisheries also recommends that Fishery Management Plans identify habitat areas of particular concern (HAPC's). The general types of HAPC include the following: nearshore areas of intertidal and estuarine habitats that may provide food and rearing for juvenile fish and shell fish managed by the Fishery Management Council (FMC); offshore areas with substrates of high habitat value or vertical relief, which serve as cover for fish and shell fish; and marine and estuary habitat used for migration, spawning, and rearing of fish and shellfish. Marine sanctuaries and national estuary reserves have been designated in the area managed by the Gulf of Mexico FMC and are considered to be HAPC's that meet the above general guidelines. These HAPC's are the Flower Garden Banks National Marine Sanctuary, Weeks Bay National Estuarine Research Reserve, and Grand Bay, Mississippi.

The requirements for an EFH description and assessment are as follows: (1) description of the proposed action; (2) description of the action agency's approach to protection of EFH and proposed mitigation, if applicable; (3) description of EFH and managed and associated species in the vicinity of the proposed action; and (4) analysis of the effects of the proposed and cumulative actions on EFH, the managed species, and associated species. Chapters 1 and 2 contain descriptions of the proposed actions. Chapters 1.5 and 2.2.2 discuss MMS's approach to the preservation of EFH with specific mitigations. Chapter 3.2.1 details coastal areas that are considered EFH including wetlands and areas of submerged vegetation. Chapter 3.2.2 describes live-bottom formations and their biotic assemblages, which are considered EFH. Below is a discussion of managed species and additional mitigating factors. Chapters 4.2.1.10 and 4.3.1.8 contain the impact analysis of the proposed actions on EFH. Chapter 4.4.3.10 contains the impact analysis for accidental spills on EFH. Chapter 4.5.10 contains the impact analysis of cumulative actions.

Managed Species

The Gulf of Mexico Fishery Management Council (GMFMC) currently describes Fishery Management Plans (FMP's) for the following species. These species or species complexes are brown shrimp (*Penaeus aztecus)*, pink shrimp (*Penaeus duorarum)*, white shrimp (*Penaeus setiferus*), royal red shrimp (*Pleoticus robustus*), red drum (*Sciaenops ocellata*), black grouper (*Mycteroperca bonaci*), red grouper (*Epinephelus morio*), gag grouper (*Mycteroperca microlepis*), scamp (*Mycteroperca phenax*), red snapper *(Lutjanus campechanus*), gray snapper (*Lutjanus griseus*), yellowtail snapper (*Ocyurus chrysurus*), lane snapper (*Lujanus syngagris*), vermilion snapper (*Rhomboplites aurorubens*), gray triggerfish (*Balistes capriscus*), greater amberjack (*Seriola dumerili*), lesser amberjack (*Seriola fasciata*), tilefish (Branchiostegidae), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), bluefish (*Pomatomus saltatrix*), cobia (*Rachycentron canadum*), dolphin (*Coryphaena hippurus*), little tunny (*Euthynnus alleteratus*), stone crab (*Menippe spp*.), spiny lobster (*Panulirus spp*.), and coral (Anthoza). None of the stocks managed by the GMFMC are endangered or threatened.

Occurrence of these managed species, along with major adult prey species and relationships with estuary and bay systems in the Eastern Gulf of Mexico, is outlined in Table 3-8. Detailed presentations of species abundance, life histories, and habitat associations for all life history stages are presented in the Generic Amendment for Essential Fish Habitat by the GMFMC (1998).

Tuna (Scombridae), billfish (Istiophoridae), swordfish (Xiphiidae), and sharks (Squaliformes) are under the direct management of NOAA Fisheries and are not included as Fishery Management Council managed species. The EFH areas for these highly migratory species (HMS) are described in separate FMP's, including the FMP for Atlantic tunas, swordfish, and sharks (USDOC, NMFS, 1999a) and the Atlantic billfish FMP Amendment 1 (USDOC, NMFS, 1996a). These separately managed species include albacore tuna (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Euthynnus pelamis*), yellowfin tuna (*Thunnus albacares*), swordfish (*Xiphias gladius*), a suite of 32 shark species (Squaliformes), and billfish (Istiophoridae) species including the blue marlin (*Makaira nigricans*), white marlin (*Tetrapturus albidus*), sailfish *Istiophorus platypterus*), and longbill spearfish (*Tetrapturus pfluegeri*). The Central and Western Gulf were reviewed for the occurrence of EFH for the 42 species above. Essentially all of these species were determined to have at least one life history stage occurring in or near the area. The GMFMC (1998) did not indicate EFH for spiny lobster (*Panulirus spp*.) or yellowtail snapper (*Ocyurus chrysurus*) in the sale areas, but both these species are known to occur on topographic features such as the Flower Garden Banks and Sonnier Bank in the CPA.

As described by NMFS documents (USDOC, NMFS, 1999a and b), the current status of the scientific knowledge of these species is such that habitat preferences are largely unknown or are difficult to determine. As in the case with shark species, it is difficult to define the habitat of sharks of this temperate zone in the Gulf of Mexico because most species are highly migratory, using diverse habitats in apparently nonspecific or poorly understood ways. Temperature is a primary factor affecting the distribution of sharks, and their movement in coastal waters are usually correlated with unpredictable seasonal changes in water temperature. Similar to the species managed by the GMFMC described above, the occurrence of these 14 species managed by NOAA Fisheries, along with major prey species, is outlined in Table 3-9. Bay and estuary relationships are not cited in the FMP's except in one instance of the bull shark where estuary areas are used as a nursery area. As additional life history information is developed, additional use of inshore and estuary area may be included as EFH in the future.

Some of these 14 highly migratory species occur beyond the 200-m water depth contour. Many of these highly migratory species such as billfishes are associated with upwelling areas where canyons cause changes in current flow (upwelling) and create areas of higher productivity.

The GMFMC's *Generic Amendment for Addressing Essential Fish Habitat Requirements* (GMFMC, 1998) identifies threats to EFH and makes a number of general and specific habitat preservation recommendations for pipelines and oil and gas exploration and production activities within State waters and OCS areas.

The general recommendations for State waters and wetlands are as follows:

(1) Exploration and production activities should be located away from environmentally sensitive areas such as oyster reefs, wetlands, seagrass beds, endangered species habitats, and other productive shallow water areas. Use of air boats instead of marsh buggies should be implemented whenever possible.

(2) Upon cessation of drilling or production, all exploration/production sites, access roads, pits and facilities should be removed, backfilled, plugged, detoxified, revegetated and otherwise restored to their original condition.

(3) A plan should be in place to avoid the release of hydrocarbons, hydrocarbon-containing substances, drilling muds, or any other potentially toxic substance into the aquatic environment and the surrounding area. Storage of these materials should be in enclosed tanks whenever feasible or, if not, in lined mud pits or other approved sites. Equipment should be maintained to prevent leakage. Catchment basins for collecting and storing surface runoff should be included in the project design.

Individual States, the COE, and the USEPA have review and permit authority over oil and gas development and production within State waters. All oil and gas activities in coastal or wetland areas must adhere to numerous conservation measures before receiving permits from these agencies. In order to minimize potential coastal impacts from OCS-related activities, the MMS has numerous safety, inspection, and spill response requirements in place to prevent an accidental release of hydrocarbons from either happening at all or from reaching land (Chapters 1.5, 4.4.1 and 4.4.2).

The *Generic Amendment* lists a number of measures that may be recommended in association with exploration and the production activities located close to hard banks and banks containing reef-building coral on the continental shelf. These recommendations are:

(1) Drill cuttings should be shunted through a conduit and discharged near the seafloor, or transported ashore, or to a less sensitive, NOAA Fisheries-approved offshore locations.

(2) Drilling and production structures, including pipelines, generally should not be located within one mile of the base of a live reef.

(3) All pipelines placed in waters less than 300 ft deep should be buried to a minimum of 3 ft beneath the seafloor, where possible. Pipeline alignments should be located along routes that minimize damage to marine and estuarine habitat. Buried pipelines should be examined periodically for maintenance of adequate earthen cover.

(4) In anchorage areas, all abandoned structures must be cut off 25 ft below the mud line. If explosives are to be used, NOAA Fisheries should be contacted to coordinate marine mammal and endangered species concerns.

(5) All natural reefs and banks, as well as artificial reef areas, should be avoided.

The *Generic Amendment* makes an additional specific recommendation regarding OCS oil and gas activities under review and permit authority by MMS and USEPA. Specifically, for the conservation of EFH, activities should be conducted so that petroleum-based substances such as drilling mud, oil residues, produced waters, or other toxic substances are not released into the water or onto the seafloor. The MMS lease sale stipulations and regulations already incorporated many of the suggested EFH conservation recommendations. Lease sale stipulations are considered to be a normal part of the OCS operating regime in the Gulf of Mexico. Compliance with stipulations from lease sales is not optional; application of a stipulation(s) is a condition of the lease sale. In addition, MMS may attach mitigating measures to an application (exploration, drilling, development, production, pipeline, etc.) and issue an NTL.

The MMS Topographic Features and Live Bottom (Pinnacle Trend) Stipulations were formulated more than 20 years ago and were based on consultation with various Federal agencies and comments solicited from State, industry, environmental organizations, and academic representatives. These stipulations address conservation and protection of essential fish habitat/live-bottoms areas. The stipulations include exclusion of oil and gas activity (structures, drilling, pipelines, production, etc.) on or near live-bottom areas (both high-relief and low-relief), mandatory shunting near high-relief features, relocation of operations including pipelines away from essential fish habitat/live bottoms, and possible monitoring to assess the impact of the activity on the live bottoms.

Mitigating measures that are a standard part of the MMS OCS Program limit the size of explosive charges used for platform removal; require placing explosive charges at least 15 ft below the mudline; establish No Activity and Modified Activity Zones around high-relief live bottoms; and require remote-sensing surveys to detect and avoid biologically sensitive areas such as low-relief live bottoms, pinnacles, and chemosynthetic communities.

In consideration of existing mitigation measures, lease stipulations, and a submitted EFH Assessment document, MMS entered into a Programmatic Consultation agreement with NMFS on July 1, 1999, for petroleum development activities in the CPA and WPA. The NMFS considered an EFH Assessment describing OCS development activities, an analysis of the potential effects, MMS's views on those effects, and proposed mitigation measures as acceptable and meeting with the requirements of EFH regulations at 50 CFR Subpart K, 600.920(g). For the 1999 Programmatic Consultation, NMFS made the following additional recommendations (as numbered within the NMFS letter of agreement):

(5) When the Live Bottom (Pinnacle Trend) Stipulation is made a part of a pipeline laying permit, MMS shall require that: No bottom-disturbing activities, including anchors from a pipeline laying barge, may be located within 100 ft of any pinnacle trend feature with vertical relief greater than or equal to 8 ft.

(6) When the Topographic Features Stipulation is made a part of a permit that proposes to use a semi-submersible drilling platform, MMS shall require that: No bottom-disturbing activities, including anchors or cables from a semisubmersible drilling platform, may occur within 500 ft of the No Activity Zone boundary.

(7) When the Topographic Features Stipulation is made a part of a permit that proposes exploratory drilling operations, MMS shall require that: Exploratory operations that drill more than two wells from the same surface (surface of the seafloor) location at any one or continuous time and within the 3-Mile Restricted Activity Zone must meet the same requirements as a development operation (i.e., drilling discharges must be shunted to within 10 m of the seafloor).

(8) When the Topographic Features Stipulation is required for any proposed permit around Stetson Bank, now a part of the Flower Gardens Banks National Marine Sanctuary (FGBNMS), the protective requirements of the East and West Flower Garden Banks shall be enforced.

(9) Where there is documented damage to EFH under the Live Bottom (Pinnacle Trend) or Topographic Features lease stipulation, MMS shall coordinate with the NMFS Assistant Regional Administrator, Habitat Conservation Division, Southeast Region for advice. Based on the regulations at 30 CFR Subpart N, 250.200, "Remedies and Penalties," the Regional Director of the MMS may direct the preparation of a case file in the event that a violation of a lease provision (including lease stipulations) causes serious, irreparable, or immediate harm or damage to life (including fish and other aquatic wildlife) or the marine environment. The conduct of such a case could lead to corrective or mitigative actions.

(10) The MMS shall provide NMFS with yearly summaries describing the number and type of permits issued in the Western and Central Planning Areas, and permits for activities located in the Live Bottom (Pinnacle Trend) and Topographic Features blocks for that year. Also, the summaries shall include a report of any mitigation actions taken by MMS for that year in response to environmental damage to EFH.

The MMS has accepted and adopted these six additional EFH conservation recommendations. Although the 1999 Programmatic Consultation agreement and associated EFH recommendations refer specifically to the CPA and WPA, the same mitigation measures and lease stipulations will be evaluated by NOAA Fisheries as part of the EFH Assessment contained in this multisale EIS for both planning areas. This will be the first multisale NEPA document including an EFH consultation with NOAA Fisheries.

Mitigating Factors

As discussed above, the Gulf of Mexico Fishery Management Council's EFH preservation recommendations for oil and gas exploration and production activities are specified and are currently being followed by MMS as mitigating actions to EFH. The MMS regulations and lease sale stipulations already incorporate many of the suggested EFH conservation recommendations. In some cases MMS works with other Federal agencies to mitigate effects in an area. In addition, MMS may attach mitigating measures as a condition of approval of an OCS plan or application (exploration, drilling, development, production, pipeline, etc.).

The subsurface portions of any structures in the areas of the proposed lease sales will act as reef material and a focus for many reef-associated species. Fisheries Management Plans specifically describe the use of artificial reefs as EFH. The EFH draft from the South Atlantic Fishery Management Council (1998) describes how manmade reefs are deployed to provide fisheries habitat in a location that provides measurable benefit to man. When manmade reefs are constructed, they provide new primary hard substrate similar in function to newly exposed hard bottom, with the additional benefit of substrate extending from the bottom to the surface. Reef structures of high profile seem to yield generally higher densities of managed and nonmanaged pelagic and demersal species than a more widespread, lower profile natural hard bottom or reef (South Atlantic Fishery Management Council, 1998). The benefits of artificial reefs created by the installation of energy production platform structures are well documented in Gulf waters of the coast of Texas and Louisiana. See Appendix 9.4 for additional information on artificial reefs and the Rigs-to-Reefs development.

3.3. SOCIOECONOMIC ACTIVITIES

3.3.1. Commercial Fishing

The Gulf of Mexico provides nearly 21 percent of the commercial fish landings in the continental U.S. on an annual basis. The most recent, complete information on landings and value of fisheries for the U.S. was compiled by NMFS for 1999. During 1999, commercial landings of all fisheries in the Gulf totaled over 1.9 billion pounds, valued at about $776 million (USDOC, NMFS, 2001b).

Menhaden, with landings of about 1.5 billion pounds and valued at $78.5 million, was the most important Gulf species in quantity landed during 1999. Landings have increased by 488.8 million pounds (40%) in the Gulf States compared to 1998. Shrimp, with landings of nearly 242 million pounds and valued at about $478 million, was the most important Gulf species in value landed during 1999. The 1999 Gulf oyster fishery accounted for nearly 67 percent of the national total with landings of 14 million pounds of meats, valued at about $28 million. The Gulf blue crab fishery accounted for 24 percent of the national total with landings of 45 million pounds, valued at about $32 million (USDOC, NMFS, 2001b).

Texas' total commercial landings in 1999 were nearly 93 million pounds valued at close to $221 million. Shrimp was the most valuable species group landed with all species combined coming to a total weight of over 73 million pounds valued at over $193 million. In addition, during 1999, the following species each accounted for landings valued at over $2 million: Eastern oyster, blue crab, black drum, and red snapper (USDOC, NMFS, 2001b).

Nearshore and offshore waters east of the Mississippi River Delta support a diverse assemblage of valuable fishery resources. These resources, in turn, support important commercial fisheries for the region. Coastal fishes of commercial importance to the northeastern Gulf include sheepshead, red snapper, scad, ladyfish, sardines, spotted seatrout, grouper, and mullet. Pelagic fishes of commercial importance make seasonal movements up and/or down the west Florida coast and back and forth between nearshore and offshore waters. Pelagic fishes of commercial importance include Spanish and king mackerel, amberjack, and several species of tuna. Important invertebrates landed along the west coast of Florida include American oyster, blue crab, and four species of shrimp (pink, white, brown, and rock).

Louisiana's total commercial landings in 1999 were 1.5 billion pounds, valued at $294 million. Shrimp was the most important fishery landed, with about 121 million pounds valued at $171 million. In addition, during 1999, the following species each accounted for landings valued at over $1 million: Atlantic menhaden, black drum, blue crab, Eastern oyster, red snapper, and swordfish (USDOC, NMFS, 2001b).

Mississippi's total commercial landings in 1999 were 267.5 million pounds, valued at $48.3 million. Shrimp was the most important fishery landed, with 14.5 million pounds valued at $34 million. In addition, during 1999, the following three species each accounted for landings valued at over $250,000: Atlantic menhaden, blue crab, and striped mullet (USDOC, NMFS, 2001b).

Alabama's total commercial fishery landings for 1999 were 27 million pounds, valued at $50.4 million. Shrimp was the most important fishery, with about 17.7 pounds landed valued at about $44.6 million. In addition, during 1999, the following two species each accounted for landings valued at over $750 thousand: blue crab and striped mullet (USDOC, NMFS, 2001b).

Total commercial landings for the west coast of Florida in 1999 were 90.2 million pounds, valued at $164.4 million. Shrimp was the most important fishery landed, with 16.0 million pounds valued at $ 39.6 million. In addition, during 1999, the following species each accounted for landings valued at over $5 million: Quahog clam (from aquaculture), blue crab, stone crabs, red grouper, striped mullet, and Caribbean spiny lobster (USDOC, NMFS, 2001b).

In April 1997, Continental Shelf Associates (CSA, 1997a) completed a study characterizing recreational and commercial fishing east of the Mississippi Delta for the period 1983-1993. A synopsis of some of the conclusions concerning commercial fisheries for the region from 1983 to 1993 is included below (CSA, 1997a), although the study emphasized the panhandle area of Florida.

Baitfishes accounted for the highest commercial landings in the region during the period 1983-1993. Menhaden contributed the greatest proportion of the entire finfish landings; however, the Florida Panhandle landings for menhaden are orders of magnitude lower than those reported in Louisiana and Mississippi. The baitfish fishery showed signs of overfishing (fishing effort increased, landings decreased) or at least great stress. If user demand continues as it has over the 1983-1993 period, a collapse in the bait fishery is a distinct possibility.

Coastal pelagic fishes, including king and Spanish mackerel, cobia, and jacks, are an important group to the commercial fisheries of the northeastern Gulf. The ladyfish or tenpounder accounted for the highest portion of the coastal pelagic landings. Gill nets and purse nets are the primary gear type used for coastal pelagic fishes. The Florida Panhandle is probably the most important fishing area for this species in the entire Gulf of Mexico (Joyce, 1983). Coastal pelagic landings fell during the period of 1983-1993. This is to be expected since both nominal and real income of the fishers is rising at rapid pace, thereby inducing more fishers and vessels into this fishery. The increase in fishing effort places stress on the coastal pelagic fishery resource, which eventually leads to overfishing.

Ranking third in landings over the period 1983-1993, behind the baitfishes and coastal pelagic fishes, were reef fishes. This species group were sought after by more fishers and included many more species than the other groups. The reef fishery also generated the highest valued finfish landings for the region. Hook-and-line, bottom longline, and traps were the most important gear types used to catch reef fishes in the northeastern Gulf of Mexico waters. Reef fishing for snappers, groupers, gray triggerfish, and amberjacks takes place in offshore shelf waters (20-200 m) over natural or artificial bottom. Certain deepwater reef fishes such as snowy, yellowedge, and warsaw groupers are fished exclusively in waters off the shelf break. Reef fishes, along with coastal pelagic fishes, are the most sought after groups by fishermen from Alabama and Florida who venture over to the oil and gas platforms off the adjacent States. The reef fish fishery showed a decline during the early years of 1983-1993 but finished the period on the rise. According to the GMFMC (1995), this may be explained by the overfishing of red snapper in the early 1980's and recent recovery in the stocks of this species due to various fishery management measures to protect this population. The rise in reef fish landings during the 1990's may also be due to a switch in fishing effort from red snapper to vermilion snapper, which became the most frequently landed reef fish during the period. Both these species have been experiencing intense fishing pressure from fishermen in Alabama and Florida regions within the past several years.

Oceanic pelagic fishes were not landed in high quantities relative to other finfish groups during 1983-1993; however, they were very valuable, ranking second to reef fishes in average dollar value of landings. The most important species, yellowfin tuna and swordfish, were caught primarily by surface longline in oceanic waters offshore of the shelf break. Because these fisheries operate in the open Gulf, catches responsible for landings in a specific State could have been made in waters outside the region. The demand for oceanic pelagic fishes accelerated very rapidly over the 1983-1986 period and leveled off over the remainder of the study period remaining rather static in terms of catch, price, and dockside value from 1987 to 1993.

The remaining group of finfishes landed by commercial fishers in the northeastern Gulf—the demersal fishes—was taken almost exclusively from inland (estuarine) waters. The primary gear types used in this fishery are purse nets and gill nets. For the period 1983-1993, striped mullet was the key species in the demersal landings, followed by spotted seatrout. These species were caught mostly by gill nets, and the number of fishing trips made annually was high compared with the other net fisheries. The mullet fishery is relatively valuable, due in part to the recent increases in demand for the roe in foreign markets. Most coastal counties in Alabama and the Florida Panhandle reported sizeable landings of striped mullet. Important variables impacting fishery landings include fishing pressure, management measures, loss of habitat, and pollution. Many of the demersal species are estuarine-dependent so the quality of the estuarine habitats is critical to maintaining catch levels. Little data is available on trends in various pollutants that could impact the juvenile and adult segments of the population in the vast system of northeastern Gulf estuaries. However, the trend from 1983 to 1993 for demersal species shows that the landings stabilized with an increase in value toward the latter part of the period. Several members of this species group, including red drum, striped mullet, and spotted seatrout, were subject to legislation during the period.

The dominant invertebrate species groups in the northeastern Gulf fisheries were shrimp, oysters, and blue crab. These three species groups were almost exclusively fished in inland (estuarine) waters. Little shrimping is done in shelf waters offshore Alabama or Florida. Some shrimping (royal red shrimp) does occur in DeSoto Canyon and in Louisiana, Mississippi, Alabama (primarily brown shrimp with some white shrimp catches), and Florida State waters (primarily pink shrimp). The value of shrimp landings exceeded that of all other fish or invertebrate species group. Shrimp were caught with otter trawls, butterfly nets, and beam trawls.

Blue crab was an important component of the invertebrate fishery. Blue crab was caught mostly by trap, but a small proportion of blue crab landings was contributed by the shrimp trawl fishery. The value of the blue crab landings was considerably less than the value of the shrimp landings. The blue crab catch in Mississippi and Alabama is an important part of the U.S. supply of this food commodity; therefore, changes in this catch greatly impact prices. However, price analysis for the period 1983-1993 shows that crab catches appear to be suffering from overfishing or environmental variables, and this is making it difficult for crab fishing to be profitable no matter what the capital outlay.

Oyster landings ranked third in weight and second in value behind shrimps for Alabama and northwest Florida. Oysters were harvested with tongs, a traditional method that is labor intensive, but allows for more a sustainable fishery than would be possible if more efficient means were to be used. The most common factor limiting the harvesting of oysters is high coliform counts or bacterial levels forming in bays and inlets, especially where the water is confined or receives limited flushing into the Gulf of Mexico. Oyster are plagued by marketing problems in that the public is increasingly aware of public health problems associated with eating oysters. The static nature of the fishing effort and technology in the oyster industry from 1983 to 1993 is consistent with a lack of productivity. The static character makes it difficult for oyster fishermen to increase profits despite increased fishing effort.

Important finfish groups landed at ports in Alabama and along Florida's northwest coast include snapper, porgies, mullet, baitfish, jacks, triggerfish, grouper, tuna, and other pelagics. Important shellfish groups landed at ports in Alabama and along Florida's northwest coast include shrimp, oysters, and crab. In July 1995, the State of Florida enacted a ban upon the use of entanglement nets (gill and purse nets but not trawls) in State waters (14.5 km offshore on the Gulf of Mexico side of the state). This law has caused a substantial drop in the landings of baitfishes, coastal pelagic, and demersal fishes throughout the Florida Panhandle.

Many commercial species harvested from Federal waters of the Gulf of Mexico are considered to be at or near an overfished condition. Continued fishing at the present levels may result in rapid declines in commercial landings and eventual failure of certain fisheries. Commercial landings of traditional fisheries, such as red snapper, vermilion snapper, spiny lobster, jewfish, and mackerel, have declined over the past decade despite substantial increases in fishing effort. Commercial landings of fisheries such as shark, black drum, and tuna, have increased exponentially in the recent years, and those fisheries are thought to be in need of conservation (Grimes et al., 1992; USDOC, NMFS, 1997).

Most recently, gag grouper joined vermilion snapper on the 1998 NMFS report's list of species "approaching overfishing" in the Gulf. Five other species — red snapper, Nassau grouper, jewfish, king mackerel, and red drum — were listed in the report as overfished in the Gulf. Shrimp stocks, the primary cash catch in the Gulf States, remain strong according to the report. The status of another 48 Gulf fishery species is described as "unknown," but at least one-third of U.S. marine fishery stocks are considered overfished (USDOC, NMFS, 1997). The number of species considered to be overfished will likely continue to rise under new, more stringent requirements of the Magnuson-Stevens Fisheries Management and Conservation Act (See Chapter 1.3 for details on the Act.).

Nearly all species substantially contributing to the Gulf of Mexico's commercial catches are estuarine dependent. The degradation of inshore water quality and loss of Gulf wetlands as nursery areas are considered significant threats to commercial fishing (USEPA, 1992 and 1994; Christmas et al., 1988; Gulf States Marine Fisheries Commission, 1988). Natural catastrophes may change the physical characteristics of offshore, nearshore, and inshore ecosystems and destroy gear and shore facilities. Hurricane Andrew, in August 1992, caused extensive damage to Gulf wetlands and killed at least \$7.8 million worth of saltwater finfish and \$3.5 million worth of oysters. Commercial fishery losses were estimated at \$54 million for the months of September and October 1992 alone (Horst, 1992a). Over \$10 million in damages to fisheries product, seafood plants, and vessels were incurred (USDOC, NMFS, 1994a). Hurricane Opal in October 1995 caused extensive damage to offshore fishing grounds in the northeastern Gulf. Examination of artificial reefs off the Florida Panhandle one year after the passage of Hurricane Opal revealed storm-related deterioration and destruction of fishing reefs (Maher, written communication, 1996).

The Gulf of Mexico shrimp fishery is the most valuable in the U.S., accounting for 69 percent of the total domestic production (USDOC, NMFS, 2001b). Three species of shrimp—brown, white, and pink—dominate the landings by weight. The status of the stocks are as follows: (1) brown shrimp yields are at or near the maximum sustainable levels; (2) white shrimp yields are beyond maximum sustainable levels with signs of overfishing occurring; and (3) pink shrimp yields are at or beyond maximum sustainable levels.

The shrimp fishery is facing a number of additional problems: too many vessels given available yields of shrimp; imports of less expensive shrimp from foreign countries, accounting for 35 percent of the value of total edible imports in 1999 (USDOC, NMFS, 2000); continued decline in ex-vessel price of domestic shrimp; other related fishing needs; increases in fuel prices; excessive costs of marine casualty insurance; regulations regarding the use of turtle excluder devices and by-catch devices; excessive bycatch of finfish; and conflicts with other targeted fisheries (Gulf States Marine Fisheries Commission, 1988; Louisiana Dept. of Wildlife and Fisheries, 1994; USDOC, NMFS, 1996). Without the use of by-catch reduction devices, it has been estimated that for every pound of shrimp landed, several pounds of valuable finfish are killed and discarded as bycatch (Sports Fishing Institute, 1989). In an attempt to lessen anticipated conflicts between commercial fishing for shrimp, spiny lobster, and stone crab, the GMFMC has closed areas in the Eastern Gulf to shrimp trawling during the traditional trap fishing seasons for lobster and stone crab.

The red drum fishery was closed to all harvest in Federal waters of the Gulf of Mexico on January 1, 1988. Stock assessment concluded that red drum were heavily fished prior to moving offshore to spawn and that those fish less than 12 years of age were poorly represented in the offshore spawning population. Continued harvest of adults from Federal waters would further reduce spawning stock and increase the risk of a collapse of the red drum fishery (USDOC, NMFS, 1989). The red drum fishery has remained closed through 2001.

Red and vermilion snapper resources in the Gulf of Mexico are believed to be severely overfished from both directed and bycatch fisheries. Red snapper is the most important species off the Central Gulf Coast in the reef fish complex managed under an FMP in terms of value and historical landings. Vermilion snapper is the second most important snapper species off the Florida west coast after yellowtail snapper. Both red and vermilion snapper are presently considered to be in worse condition than was the red drum when that fishery was closed to all further harvest in Federal waters (Goodyear and Phares, 1990; Horst, 1992b; USDOC, NMFS, 1989).

The major concern of the stone crab fishery is whether harvest has reached or exceeded maximum sustainable yield. Until recently, the fishery has been expanding in terms of increasing catch within traditional fishing areas, as well as previously unfished or underfished regions. However, the total harvest has declined steadily over the past several years. The GMFMC is considering limitations on the number of fishermen and traps in the stone crab fishery.

The coastal pelagic FMP addresses a number of species. Two of the more important species are king and Spanish mackerels. Both species have been extensively overfished in the past and are now under a managed rebuilding program. The commercial fishery for king mackerel is closed in the western Gulf when a quota of 1.01 million pounds is reached. From the early 1980's to 1990's, there has been a marked absence of a strong year-class of king mackerel. Spawning stock biomass has exhibited gains. There is concern about the possible need for two management units for king mackerel within the Gulf of Mexico and about the impact of the increasing Mexican fishery. Spanish mackerel stocks are showing positive signs of recovery. Spawning stock biomass and recruitment appear to be increasing. Both commercial and recreational bag limits were increased in June 2000 by the GMFMC. Most of the Spanish mackerel catch is taken off Florida. Capture of 50-80 percent of the yearly commercial allocation within a period of three weeks by southeast Florida fishermen has raised questions of conflict with recreational fishermen who believe their allocation should be increased.

Commercial landings of swordfish have increased steadily over the past several years with serious implications for the future. The percentage of older fish and spawning biomass has declined significantly. The GMFMC is developing a number of alternatives to better manage this resource.

Blue marlin and white marlin are believed to be at or near the point of full exploitation. There is concern about the increasing mortality of marlin as bycatch associated with the escalating yellowfin tuna longline fishery (Sports Fishing Institute, 1989). The tuna fishing industry has expanded at an alarming rate in the Gulf of Mexico over the past five years. Tuna are now included under the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA), and the GMFMC can begin to manage the tuna fishing industry and address the marlin bycatch issue.

The taking of stony corals or gorgonian sea fans is prohibited. Fishing for soft coral octocorals is presently below the limits of maximum yield. There are major concerns about the butterfish fishery in that butterfish trawlers allegedly destroy coral reef habitat and take a large number of snappers and groupers as bycatch. In addition, a newly formed fishery of "live rock" for the ornamental trade is receiving attention due to the allegation that "live rock" fishing may purposefully or inadvertently include the harvest of stony coral. Amendment 2 to the FMP for coral and coral reefs specifically addresses the concerns of "live rock" harvest in the Gulf of Mexico (GMFMC, 1994). The coral/live rock resources were originally managed jointly by the Gulf and South Atlantic Fishery Management Councils (SAFMC). This changed in 1995 when the Councils separated their management of this group. The SAFMC passed a further amendment to the SAFMC Coral FMP in 1995 that established a separate fishery management plan for "live rock." The FMP restrictions apply only to the Atlantic coast of Florida and not to the Gulf of Mexico. No amendments for "live rock" management have been issued by the GMFMC since 1994.

The present concern with the condition of the black drum fishery stems directly from the closure of the red drum fishery. Almost immediately after closure, black drum and sheepshead were accepted as a substitute for red drum within the commercial market. The intensive fishing effort for red drum was switched to black drum and sheepshead without need to change fishing gear or technique. As a result, stocks of these two fish species are believed to be fast approaching a seriously depleted condition. Louisiana, Mississippi, and Alabama have instituted interim management measures in State waters to reduce black drum catches while an FMP is developed and implemented (Horst, 1993).

A strong market for shark has resulted in soaring catches over the past several years, though the value is low. Shark stocks are unable to sustain the present heavy fishing pressure, and without management, the fishery is expected to collapse within the near future. The GMFMC requested that Gulf States consider management measures within State waters and issued an FMP for both coastal and pelagic sharks (Justen, 1992).

Today, most of the effort expended on understanding what controls fishery populations focuses on the effects of fishing. Although most population models used in fisheries management take into account natural mortality, fishing mortality is the only variable that can be accurately estimated and controlled. Thus, while management focuses almost exclusively on controlling fishing effort, the success of any management scheme is dependent on understanding factors other than fishing that influence or regulate population abundance. Recent proposals by NOAA Fisheries are examples of attempts to conserve fish populations by increasing constraints on fishing efforts (GMFMC, 2000).

Grouper species can be overfished because they aggregate in great numbers, year after year in the same locations during spawning; during that time the males are especially susceptible to being caught. The NOAA Fisheries hopes to spare the spawning population by using closed seasons and Marine

Protected Areas (MPA's) as a management tool. But while the concept has its benefits, fishermen are also wary about the number of fishing grounds that could become off-limits to them if MPA's become numerous. The question is: Are MPA's the panacea for fisheries management woes or just a valuable alternative to other management techniques? Two MPA's have been designated of the west Florida shelf that are now closed to all fishing except for pelagics. They are named the Madison and Swanson site (115 nmi^2), south of Panama City, Florida, and Steamboat Lumps (104 nmi^2), west of Tarpon Springs, Florida. The two grouper reserves are now a reality and went into effect on June 19, 2000. In addition, a sunset provision has been added after four years so that the effects of the closed areas can be evaluated. Both of the areas are along the 70- to 80-m depth contour. The Madison and Swanson site south of Panama City is a high-relief site. Steamboat Lumps, west of Tarpon Springs, is the lower portion of the original 423-nmi^2 closed-area proposal. It is a low-relief site that has been reported by fishermen to be a good area for gag spawning.

Another NOAA Fisheries' proposal has been made to reduce longliner bycatch, especially of billfish, by issuing a longlining ban in the Gulf of Mexico and along the southeastern Atlantic coast. This proposal has drawn opposition from sport and commercial swordfish fishermen, as well as from seafood dealers, albeit for different reasons in each case. All waters of the EEZ would be subject to the closure for longline fishing from March 1 to September 30 each year in the western Gulf of Mexico. In the Atlantic between Key West, Florida, and Georgetown, South Carolina, the closure would be year-round. Closures would not affect bottom fishermen, who target grouper and sharks. Longliners stated to the GMFMC that 80 percent of their catch comes from the western Gulf and that the proposal would put them out of business. Sport fishermen said the proposal would leave the Eastern Gulf open to longliners. In addition, commercial fishermen questioned the wisdom of the NOAA Fisheries' proposal, given, they said, that Mexico has no restrictions on longlining or catching billfish, which migrate between U.S. and Mexican waters. Shoreside interests said their businesses—shipyards, marine electronics dealers, fuel suppliers, freight handlers, restaurants, and seafood distributors—would also suffer as a result of the ban. The NOAA Fisheries was urged to consider alternatives, such as requiring circle hooks, which are designed not to snag fish that do not hit the bait, and a ban on live bait. On August 4, 2000, the NOAA Fisheries (formerly NMFS) announced some new regulations to reduce bycatch and bycatch mortality in the pelagic longline fishery. On November 1, 2000, NOAA Fisheries (formerly NMFS) put into effect a new regulation to reduce bycatch and bycatch mortality in the pelagic longline fishery. Two rectangular areas in the Gulf of Mexico (one of which lies over a portion of the region known as DeSoto Canyon) are closed year-round to pelagic longline fishing. These closed areas cover 32,800 mi^2 (Figure 3-9). This region has been identified by NOAA Fisheries as a swordfish nursery area, where there has historically been a low ratio of swordfish kept to the number of undersized swordfish discarded, which over the period of 1993-1998 has averaged less than one swordfish kept to one swordfish discarded. The area closure is expected to produce approximately a 4 percent reduction in Gulf and Atlantic undersized swordfish bycatch. The DeSoto Canyon area coordinates are as follows:

Upper Area

North boundary:	30 °N. latitude
South boundary:	28 °N. latitude
East boundary:	86 °W. longitude
West boundary:	88 °W. longitude

Lower Area

North boundary:	28 °N. latitude
South boundary:	26 °N. latitude
East boundary:	84 °W. longitude
West boundary:	86 °W. longitude

Only a very small portion of the "upper area" includes lease blocks in the CPA. All of the "lower area" and most of the upper area are located in the EPA.

The increasing and often confusing restrictions, constraints, license costs, certifications, and general limitations has the fishing industry wondering if it has a viable future. Until the late 1980's most commercial fishing endeavors in the Gulf of Mexico had relatively few constraints. Commercial fishermen are becoming more organized and have hired fisheries consultants and attorneys to challenge the system as they see it.

Compared with the development of deep-sea fisheries by other countries, the United States has developed only a few of its deep-sea resources. Upper ocean trolling, mixed-depth longlining, deep bottom trawling, and deep bottom longlining are practiced on a limited basis in deepwater areas of the Eastern Gulf of Mexico. Deep-sea fishing includes commercial efforts and charter boats for hire. The equipment and practice of deepwater fishing are substantial in terms of size, weight, time, and expense.

Despite encouragement from NOAA Fisheries, fewer than 10 commercial fishermen are known to harvest benthic species from the DeSoto Canyon region. Royal red shrimp has been harvested by fishers for at least a decade from areas in DeSoto Canyon. Due to the depth (200-400 m; 656-1,312 ft), which requires specialized gear, time involved, and the localized, spotty nature of this shrimp species, trawling and harvest have been the effort of a very small number of focused fishermen. It is unlikely that fishing for this species will increase in the future.

Commercial fishing for tilefish in the Eastern Gulf is done with bottom longlines. Tilefish species represent a typical deep-sea resource that is long-lived, slow to develop, and reproduce with limited numbers of offspring (Moore, 1999). Tilefish show an affinity for a sandy bottom, where they sit in indentations or burrows in the ocean floor. Because of their life history, tilefish are easily overfished and depleted. A sporadic, commercial harvest of golden tilefish on the eastern shoulder of DeSoto Canyon and along the Florida shelf-slope break is several decades old. Harvest is intermittent and limited within the Gulf due to depleted populations. Tilefish are found in water from 240 to 400 ft (73-122 m) in depth, which requires the use of highly selected gear.

3.3.2. Archaeological Resources

Archaeological resources are any material remains of human life or activities that are at least 50 years of age and that are of archaeological interest (30 CFR 250.2). The Archaeological Resources Regulation (30 CFR 250.26) provides specific authority to each MMS Regional Director to require archaeological resource surveys, analyses, and reports. Surveys are required prior to any exploration or development activities on leases within the high probability areas (NTL 2001-G01).

3.3.2.1. Historic

With the exception of the Ship Shoal Lighthouse structure, historic archaeological resources on the OCS consist of historic shipwrecks. A historic shipwreck is defined as a submerged or buried vessel, at least 50 years old, that has foundered, stranded, or wrecked and is presently lying on or embedded in the seafloor. This includes vessels that exist intact or as scattered components on or in the seafloor. A 1977 MMS archaeological resources baseline study for the northern Gulf of Mexico concluded that two-thirds of the total number of shipwrecks in the northern Gulf lie within 1.5 km of shore and most of the remainder lie between 1.5 and 10 km of the coast (CEI, 1977). A subsequent MMS study published in 1989 found that changes in the late 19th- and early 20th-century sailing routes increased the frequency of shipwrecks in the open sea in the Eastern Gulf to nearly double that of the Central and Western Gulf (Garrison et al., 1989). The highest observed frequency of shipwrecks occurred within areas of intense marine traffic, such as the approaches and entrances to seaports and the mouths of navigable rivers and straits.

Garrison et al. (1989) lists numerous shipwrecks that fall within the CPA and WPA. Many of these reported shipwrecks may be considered historic and could be eligible for nomination to the National Register of Historic Places. Most of these wrecks are known only through the historical record and, to date, have not been located on the ocean floor. The Garrison study lists 561 wrecks in the CPA and 615 wrecks in the WPA. These wrecks are listed by planning area in Table 3-10. This list should not be considered an exhaustive list. Regular reporting of shipwrecks did not occur until late in the 19th century, and losses of several classes of vessels, such as small coastal fishing boats, were largely unreported in official records.

Submerged shipwrecks off the coasts Texas, Louisiana, and Alabama are likely to be moderately well preserved because of the high sediment load in the water column from upland drainage and wind and water erosion. Wrecks occurring in or close to the mouth of bays would have been quickly buried by transported sediment and therefore protected from the destructive effects of wood-eating shipworms (*Teredo navalis*) or storms (Anuskiewicz, 1989, page 90). A good example of this type of historic wreck is the *la Belle* a shallow draft French sailing vessel classified as a *barque longue* lost in 1686 and discovered in Matagorda Bay, Texas, in 1995 (Ball, personal communication, 2001). Wrecks occurring in deeper water also have a moderate to high preservation potential. In the deep water, temperature at the seafloor is extremely cold, which slows the oxidation of ferrous metals. The cold water would also eliminate wood-eating shipworms. There have been two recent deepwater shipwreck discoveries in the CPA both off the mouth of the Mississippi River and lying about 35 mi apart. These wrecks were discovered by the oil and gas industry during required MMS remote-sensing surveys.

These discoveries include an early 19th-century wooden sailing vessel lying in nearly 2,700 ft of water. There are also two victims of a Gulf of Mexico WWII sea battle—the American passenger liner *Robert E. Lee* and the German submarine ***U-166*.** After sinking the *Robert E. Lee*, the *U-166* was immediately attacked by a Coast Guard patrol boat and sunk. Both vessels lie a mere 4,000 ft apart in 5,000 ft of water. All three wrecks have been investigated using a remotely-operated vehicle from a surface vessel and are in an excellent state of preservation.

Aside from acts of war, hurricanes cause the greatest number of wrecks in the Gulf. Wrecks occurring as a result of an extreme violent storm are more likely to be scattered over a broad area. The wreckage of the 19th-century steamer *New York*, which was destroyed in a hurricane, lies in 16 m of water and has been documented by MMS (Irion and Anuskiewicz, 1999) as scattered over the ocean floor in a swath over 1,500 ft long. Shipwrecks occurring in shallow water nearer to shore are more likely to have been reworked and scattered by subsequent storms than those wrecks occurring at greater depths on the OCS. Historic research indicates that shipwrecks occur less frequently in Federal waters. These wrecks are likely to be better preserved, less disturbed, and, therefore, more likely to be eligible for nomination to the National Register of Historic Places than are wrecks in shallower State waters.

3.3.2.2. Prehistoric

Available evidence suggests that sea level in the northern Gulf of Mexico was at least 90 m, and possibly as much as 130 m, lower than present sea level and that the low sea-stand occurred during the period 20,000-17,000 years Before Present (B.P.) (Nelson and Bray, 1970). Sea level in the northern Gulf reached its present stand around 3,500 years B.P. (Pearson et al., 1986).

During periods that the continental shelf was exposed above sea level, the area was open to habitation by prehistoric peoples. The advent of early man into the Gulf of Mexico region is currently accepted to be around 12,000 years B.P. (Aten, 1983). The sea-level curve for the northern Gulf of Mexico proposed by Coastal Environments, Inc. (CEI) suggests that sea level at 12,000 B.P., would have been approximately 45-60 m below the present day sea level (CEI, 1977 and 1982). On this basis, the continental shelf shoreward of the 45- to 60-m bathymetric contours have potential for prehistoric sites dating after 12,000 B.P. Because of inherent uncertainties in both the depth of sea level and the entry date of prehistoric man into North America, MMS adopted the 12,000 years B.P. and the 60-m water depth as the seaward extent of the prehistoric archaeological high-probability area.

Based on their 1977 baseline study, CEI (1977) proposed that sites analogous to the types of sites frequented by Paleo-Indians can be identified on the now-submerged shelf. Geomorphic features that have a high probability for associated prehistoric sites include barrier islands and back-barrier embayments, river channels and associated floodplains and terraces, and salt-dome features. Remote-sensing surveys have been very successful in identifying these types of geographic features, which have a high probability for associated prehistoric sites. Recent investigations in Louisiana and Florida indicate the mound-building activity by prehistoric inhabitants may have occurred as early as 6,200 B.P. (cf. Haag, 1992; Saunders et al., 1992; Russo, 1992). Therefore, manmade features, such as mounds, may also exist in the shallow inundated portions of the OCS.

Regional geological mapping studies by MMS allow interpretations of specific geomorphic features and assessments of archaeological potential in terms of age, the type of system the geomorphic features belong to, and geologic processes that formed and modified them. The potential for site preservation must also be considered as an integral part of the predictive model. In general, sites protected by sediment overburden have a high probability for preservation from the destructive effects of marine transgression. The same holds true for sites submerged in areas subjected to low wave energy and for sites on relatively steep shelves during periods of rapid rise in sea level. Though many specific areas in the Gulf having a high potential for prehistoric sites have been identified through required archaeological surveys, industry generally has chosen to avoid these areas rather than conduct further investigations.

Holocene sediments form a thin veneer or are absent over the majority of the continental shelf off western Louisiana and eastern Texas (USDOI, MMS, 1984). Many large, late Pleistocene, fluvial systems (e.g., the Sabine-Calcasieu River Valley) are within a few meters of the seafloor in this area. Further to the south and west, a blanket of Holocene sediments overlays the Pleistocene horizon. In the Western Gulf, prehistoric sites representing the Paleo-Indian culture period through European contact have been reported. The McFaddin Beach site, east of Galveston in the McFaddin National Wildlife Refuge, has produced late Pleistocene megafaunal remains and lithics from all archaeological periods, including a large percentage of Paleo-Indian artifacts (Stright et al., 1999). A study funded by MMS to locate prehistoric archaeological sites in association with the buried Sabine-Calcasieu River Valley was completed in 1986 (CEI, 1986). Five types of relict landforms were identified and evaluated for archaeological potential. Coring of selected features was performed, and sedimentary analyses suggested the presence of at least two archaeological sites.

Surveys from other areas of the western part of the CPA have produced evidence of floodplains, terracing, and point-bar deposits in association with relict late Pleistocene fluvial systems. Prehistoric sites associated with these features would have a high probability for preservation. Salt diapirs with bathymetric expression have also been recorded during lease-block surveys in this area. Solution features at the crest of these domes would have a high probability for preservation of associated prehistoric sites. The Salt Mine Valley site on Avery Island is a Paleo-Indian site associated with a salt-dome solution feature (CEI, 1977). The proximity of most of these relict landforms to the seafloor facilitates further investigation and data recovery.

3.3.3. Human Resources and Land Use

The addition of any new human activity, such as oil and gas development resulting from a proposed lease sale, can affect local communities in a variety of ways. Typically, these effects are in the form of people and money, which can translate into changes in local social and economic institutions and land use. In this section, MMS describes the current socioeconomic analysis area baseline in order to differentiate the effects of the proposed actions (Chapters 4.2.1.14 and 4.3.1.12).

3.3.3.1. Socioeconomic Analysis Area

3.3.3.1.1. Description of the Analysis Area

The MMS defines the analysis area for potential impacts on population, labor, and employment as that portion of the Gulf of Mexico coastal zone whose social and economic well-being (population, labor, and employment) is directly or indirectly affected by the OCS oil and gas industry (Figure 4-1). This analysis area is based on the results of the recent MMS socioeconomic study "Modeling the Economic Impacts of Offshore Oil and Gas Activities in the Gulf of Mexico: Methods and Applications; Final Draft" (Dismukes et al., in preparation). Geographically the analysis area is defined as all coastal counties and parishes along the U.S. portion of the Gulf of Mexico and any inland counties and parishes where offshore oil and gas activities are known to exist, offshore-related petroleum industries are established, or one or more counties or parishes within a Metropolitan Statistical Area (MSA) are on the coast. For examination purposes, MMS has divided the analysis area into subareas. The counties and parishes included in each subarea are presented in Figure 4-1. Note that coastal Subareas TX-1 and TX-2 correspond to the offshore WPA; coastal Subareas LA-1, LA-2, LA-3, and MA-1 correspond to the CPA; and coastal Subareas FL-1, FL-2, FL-3, and FL-4 correspond to the EPA.

One of the objectives of the above-mentioned study was to allocate expenditures from the offshore oil and gas industry to the representative onshore subarea where the dollars are spent. Table 3-11 presents these findings in percentage terms. Table 3-11, the IMPLAN number is the code given to the industry (sector) by the input-output software (IMPLAN) used to calculate impacts in Chapters 4.2.1.14 and 4.3.1.12. It is analogous to the standardized industry code (SIC). Table 3-11 makes clear the reasons for including all of the Gulf of Mexico subareas in the economic analysis area. Expenditures to several sectors are either exclusively found in Texas or make up a very large percentage of the total. In addition, a large percentage of total sector expenditures is allocated to each Louisiana subarea. As shown in Table 3-11, very little has been spent in the Florida subareas. This is to be expected given the lack of offshore leasing in this area and the State of Florida's position on oil and gas development off their beaches.

3.3.3.1.2. Land Use

The primary region of geographic influence of the proposed actions is coastal Texas and Louisiana with a lesser influence on coastal Mississippi and Alabama. Few offshore oil and gas activities occur in the Florida area. The coastal zone of the northern Gulf of Mexico is not a physically, culturally, or economically homogenous unit (Gramling, 1984). The counties and parishes along the coasts of Texas, Louisiana, Mississippi, and Alabama represent some of the most valuable coastline in the United States. Not only does it include miles of recreational beaches and the protection of an extended system of barrier islands, but it also has deepwater ports, oil and gas support industries, manufacturing, farming, ranching, and hundreds of thousands of acres of wetlands and protected habitat. These counties and parishes vary in their histories and in the composition and economic activities of their respective local governments.

Figure 3-10 illustrates the analysis area's key infrastructure. Major cities in the analysis area include Houston, Texas; Baton Rouge and New Orleans, Louisiana; and Mobile, Alabama. Other important cities in the analysis area include Corpus Christi, Galveston, Port Aurthur, and Beaumont, Texas; Lake Charles and Lafayette, Louisiana; and Pascagoula, Mississippi. Several international and regional airports are located throughout the analysis area. One major interstate (I-10) traverses the area along the inner margin of the coastal zone while six interstate highways access the area longitudinally. There are numerous highways into and across the analysis area. On November 28, 1995, LA Hwy 1 was designated as part of the National Highway System (NHS). The NHS Act designated 160,955 mi of interstate, highways, and other roads that are critical for the economy, defense, and mobility of the Nation as the NHS. "These highways provide access to major ports, airports, rail stations, public transit facilities, and border crossings. They comprise only 4 percent of total highways in the country; however, they carry nearly 50 percent of total highway traffic including the majority of commercial and tourism traffic. They are estimated to service more than 90 percent of businesses and industries through out the nation." (LA Hwy 1 Project Task Force, 1999). LA Hwy 1 was designated because of "its intermodal link to this Nation's energy supply" (LA Hwy 1 Project Task Force, 1999). The area's railroad configuration is similar to the highway system. An extensive maritime industry exists in the analysis area. Major ports and waterways are discussed in detail in Chapter 3.3.3.6, while Chapter 3.3.3 describes OCS-related coastal infrastructure. A listing of major public, recreational, and conservation areas are presented in Chapter 3.3.4.

The Gulf coastal plain of Texas makes up most of eastern and southern Texas and occupies more than one-third of the State. Near the coast this region is mostly flat and low-lying. It rises gradually to 300 m (1,000 ft) farther inland, where the land becomes more rolling. Belts of low hills cross the Gulf coastal plain in many areas. In the higher areas the stream valleys are deeper and sharper than those along the coast. Texas' coastline along the Gulf of Mexico is 591 km (367 mi). However, long narrow islands called barrier islands extend along the coast; if the shoreline of all the islands and bays is taken into account, the coastline is 5,406 km (3,359 mi) long (Internet website: http://www.encarta.msn.com). The region is made up of farmland (cotton, rice, and citrus fruit), forest, cattle ranches, major cities of commerce (Houston) and education, tourist locales (South Padre Island), Federal installations (e.g., Lyndon B. Johnson Space Center), and major ports. The oil and gas industry has also been part of the local economies since the early 1900's. Today, the majority of oil and gas corporations have headquarters in Houston, while numerous industries associated with oil and gas (petrochemicals and the manufacture of equipment) are located in the area. In addition to oil and gas, the area has aggressively pursued technology companies such as computers and aerospace. The military has had a significant presence in general, particularly in the Corpus Christi Bay area, and more recently in San Patricio County on the eastern shore of the bay.

The Louisiana coastal area includes broad expanses of coastal marshes and swamps interspersed with ridges of higher well-drained land along the courses of modern and extinct river systems. Most of the urban centers in coastal Louisiana are located along major navigable rivers and along the landward edge of the coastal zone (i.e., Lafayette and Lake Charles). Southwestern Louisiana is Acadian country. The area's natural features vary from marshland, waterways, and bayous in the coastal areas to flat agricultural lands in the northern part of the same parishes. While the area's traditionally strong ties to agriculture, fishing, and trapping are still evident, they are no longer the mainstay of the economy. Southeastern Louisiana, from Jefferson Parish east to St. Tammany Parish and the state border with Mississippi, is a thriving metropolitan area with shipping, navigation, U.S. Navy facilities, and oil and chemical refineries, all vying with local residents for land. Historically, Terrebonne and Lafourche Parishes have been the primary staging and support area for offshore oil and gas exploration and development. The Port of Fourchon, at the mouth of Bayou Lafourche on the Gulf of Mexico, is a major onshore staging area for OCS oil and gas activities in the CPA and WPA and the headquarters of LOOP. Chapter 3.3.3.2 above discusses the Port Fourchon area in detail.

Coastal Mississippi is characterized by bays, deltas, marshland, and waterways. Two-thirds of this coast is devoted to State-chartered gambling barges and heavy tourism along the beachfront. The remaining third (Jackson County) is industrial—oil refining and shipbuilding. Upland portions of the three coastal counties—Hancock, Harrison, and Jackson—are timberlands. Jackson County has a strong industrial base and designated industrial parks. Pascagoula, in Jackson County, is home to Ingalls Shipyard and Chevron's Pascagoula Refinery. Bayou Casotte, also in Jackson County, currently has boat and helicopter facilities, and the onshore support base for drilling and production.

Southwestern Alabama's coastline is comprised of Mobile and Baldwin Counties, which oppose each other across Mobile Bay. Coastal resource-dependent industries in this area include navigation, tourism, marine recreation, commercial fishing, and most recently, offshore natural gas development and production. Large quantities of natural gas were discovered in Alabama's offshore waters in 1979. Baldwin County has a strong tourism economy and a large retiree population. The important commercial fishing industry in the area is located in southeastern Mobile County. The Port of Mobile, the largest seaport in Alabama, is also in Mobile County. The military has had a long presence in the area. The buildup and downsizing of military installations has handed the area some special challenges. There are several oil- and gas-related businesses, including Mobil's MaryAnn/823 plant, established in 1990, and Shell's Yellowhammer plant, founded in 1989; both of these plants process natural gas (Harris InfoSource, 1998).

3.3.3.2. How OCS Development Has Affected the Analysis Area

The following section presents a brief, general narrative of how OCS development has affected the analysis area over the last 20 years. This narrative is followed by a specific account of how OCS development has affected certain locales in the analysis area.

1980-1989

In the oil and gas industry, drilling-rig use is employed as a barometer of economic activity. Between the end of 1981 and mid-1983, drilling-rig activity in the Gulf of Mexico took a sharp downturn. By 1986, the demand for mobile drilling rigs had suffered an even greater decline due to a collapse in oil prices. Population and net migration paralleled these fluctuations in mobile drilling rig activity. Population growth rates for all subareas were relatively high prior to 1983; families moved to the Gulf of Mexico coast looking for work in the booming oil and gas industry. Lower rates of population growth accompanied the decline in drilling activity as workers were laid off and left the area in search of work elsewhere. After 1983, all subareas experienced several years of significant net migration out of the region. In 1986 the demand for mobile rigs declined to its lowest level in over a decade. This negative trend on population continued through the late 1980's.

1990-1997

In the early to mid-1990's, the analysis area experienced a major resurgence in oil exploration and drilling in response to advances in technology and the enactment of the Deep Water Royalty Relief Act in 1995. The renewed interest in oil and gas exploration and development in the Gulf of Mexico produced a modest to significant recovery from the high unemployment levels experienced after the 1986 downturn. Ironically, the Gulf of Mexico coast encountered a shortage of skilled labor in the oil and gas industry as the oil industry restructured to centralize management, finance, and business services, and new generation computer technologies were applied during the downturn (Baxter, 1990). Workers who previously lost high-paying jobs in the oil industry (or oil-service industry) during the 1980's downturn were reluctant to return. This "shadow effect," coupled with the shortage of skilled labor where the core problems were lack of education and/or training for requisite skills, created a situation where temporary communities of workers from out of the area (some from out of the country) were established. Furthermore, the higher skill levels required by deepwater development drilling could not be completely met by the existing impact areas' labor force, causing in-migration. Unemployment in the analysis area, though, declined due to increased economic diversification in the region.

1998-Present

In early 1998, crude oil prices were hovering near 12-year lows due in part to economic developments in East Asia and resulting oversupply of oil (USDOE, EIA, 2001a). This restrained the resurgence of exploration and development activity in the Gulf of Mexico. While offshore development strategy varied by company, most major oil companies, diversified firms, and small independents cut back production and curtailed exploration projects. Several large integrated companies resorted to layoffs and mergers as ways to show profitiablity in a low-price environment. Redistribution of industry personnel from the New Orleans area to the Houston area also occurred. Unemployment in the analysis area rose. Offshore drilling strategies focused on mega and large prospects, foregoing small prospects, and only considering medium prospects when prices rose (Rike, 2000). A few companies, though, took advantage of lower drilling rates during this period and increased their drilling. Concurrently, technological innovations (such as the availability of 3-D seismic data, slim-hole drilling, and hydraulic rigs) decreased the cost of exploration and thus stimulated the discovery and development of large or mega prospects that were considered economic at low prices.

In March 1999, OPEC, which produces 40 percent of the world's oil, announced crude oil production cutbacks. Full member compliance increased oil prices to 20-year highs, encouraging moderate exploration and development spending in 1999. Crude oil prices continued to increase during 2000 and hold into 2001. It is generally believed that the increase in price is being driven by two major factors. First is the determination by OPEC to maintain prices within their current output targets of a $22 minimum and a $28 maximum per barrel crude oil price. The second factor is the world capacity to supply oil has not kept pace with the growth of oil demand spurred by a resurgent world economy. Furthermore, a short supply of oil tankers, rising shipping rates, and low inventories of refined product and crude oil have added upward pressure to spot crude oil prices (Brown, 2000). The prices throughout much of the 1990's were too low to stimulate additions to capacity. In addition, many tankers were scrapped in the 1990's when weak demand, low shipping rates, and increasing environmental regulation put a lot of pressure on the tanker industry (Brown, 2000).

Federal environmental/clean-air efforts in the 1990's and high oil prices in the late 1990's prompted some industries to switch from crude oil to natural gas. This development was and continues to be especially prevalent in the electricity generating industry. Natural gas, in addition to heating about 53 percent of American homes, is also being used to generate about 16 percent of the country's electricity – a percentage that is still growing (Simmons, 2001). Like crude oil, the supply of natural gas did not keep up with demand, which pushed prices higher. In December 2000, the price of natural gas broke record highs, closing at $10.10 per 1,000 cubic feet. In recent months, however, natural gas prices have decreased as much as 75 percent. Several factors have kept a downward pressure on natural gas prices in 2002. These factors include moderate weather in most of the Nation, which has kept the demand for gas by electricity generators in check; relatively low oil prices; and a general economic slowdown that began in 2001, which has reduced demand for gas by the industrial sector (FERC, 2001). Even without this pronounced drop in price, demand growth for natural gas is expected to be strong during the next 20 years. The 2001 Update of the Fueling the Future: Natural Gas and New Technologies for a Cleaner 21st Century report projects that natural gas demand would increase by 53 percent by the year 2020 (American Gas Association, 2001).

Recent technological advances and the passage of the Deep Water Royalty Relief Act in 1995 have stimulated deepwater leasing and subsequent exploration and development activities. Needs specific to these deepwater projects have resulted in more focused stresses placed on areas that are capable of supporting large-scale development projects (e.g., ports that can handle deeper draft service vessels such as Port Fourchon, Louisiana), which in turn has resulted in stresses to infrastructure servicing these focal points (particularly highways and ports), as well as placing stresses on the infrastructure associated with the focal point. This is what has occurred at Port Fourchon.

Port Fourchon, Louisiana, located at the mouth of Bayou Lafourche, is one of the main service-supply bases for offshore oil and gas exploration and development in the Gulf of Mexico. While the port has maintained steady growth over the last 25 years, the escalation of deepwater activities has produced rapid growth at the port in the last 5 years, as the port has become one of the OCS Program's focal points. More than 82,500 offshore workers use the port for helicopter transportation each year. Approximately 170 OCS-related vessels travel in and out of the port each day (based on monthly helicopter and daily vessel logs). In addition to more than 130 OCS oil- and gas-related businesses, the Louisiana Offshore Oil Port (LOOP) facilities are located at the port. The LOOP is the only offshore oil terminal in the U.S.; it transports an estimated 13-15 percent of the Nation's imported crude oil. The LOOP is expanding its storage capabilities with three large, above-ground tanks in Galliano, Louisiana. Shell and BP operations are based from the port, while all three major helicopter companies (ERA, PHI, and Air Logistics) have heliports at the port. The ERA is currently building a larger $4 million heliport at the port; it is expected to be completed in 2002. Air Logistics is planning to build a similar facility. Halliburton, another port tenant, recently completed a state-of-the-art drilling liquids facility. ChevronTexaco has tank farms at the port. Seven ship and barge repair facilities are located at the port. In addition, the port has five barge lines and six barge fleeting operations.

In 1996, Edison Chouest Offshore (Chouest) built its highly successful C-Port at Port Fourchon. The C-Port is a multi-services port terminal facility supplying offshore vessels that operate in the Gulf of Mexico. The C-Port can load/offload deck cargoes, fuel, water, cements, barite muds, liquid muds, and completion fuels simultaneously. These services are provided under the protection of a covered building, eliminating weather and darkness, while improving safety and efficiency, making it a highly cost-effective, cost-saving solution (Edison Chouest, 2001). Prior to C-Port, it took 2-3 days to service a vessel; today, service time is down to a few hours. This results in huge dollar savings for offshore companies. In addition, the companies need to lease fewer service boats because of the larger, technologically advanced ships that Chouest is building. In 1999, Chouest completed a second C-Port at Port Fourchon, C-Port 2; three additional slips are planned for C-Port 2 in 2002. Together, C-Port and C-Port 2 are servicing 90 percent of OCS deepwater activity. In addition to the port expansion, Chouest began an aggressive "new build" program in the late 1990's for their offshore service vessels. The company has produced over 50 new generation offshore vessels to serve deepwater oil and gas production. The new vessels are larger (260 ft in length) and faster than their predecessors servicing shallow-water activities. The C-Ports and the new deepwater service vessels have increased activity at Port Fourchon greatly. Chouest has also started constructing a C-Port at Galveston, Texas, to service deepwater activities in the WPA and is looking into locations in Mississippi and Alabama to build a C-Port to service deepwater activities in the EPA.

Based on OCS activity at the port, the Corps of Engineers (COE) justified deepening Port Fourchon's channel from 12 ft to 24 ft. The port had been maintaining the channel at 20 ft for the larger OCS supply vessels. In August 2001, the COE dredged the channel to a depth of 26 ft (24 ft plus 2 ft of advance maintenance) and will maintain this depth in the future.

To date, this focusing of offshore service activities at Port Fourchon has resulted in both positive and negative impacts on the area. Lafourche Parish, where the port is located, has one of the lowest unemployment rates in the nation, but its citizens' quality of life has decreased. The most significant negative impacts include

- increased OCS activity is straining the local infrastructure;
- the area is suffering with a substandard highway that will not be able to handle the truck traffic increase anticipated from OCS activities;
- severe coastal erosion is eating away the State's hurricane protection, endangering the infrastructure and industry; and
- saltwater intrusion from coastal erosion is impacting the drinking water supply.

Louisiana Highway 1 (LA Hwy 1), largely a rural substandard two-lane road, is the only land-based transportation route to the port. Results from an MMS-funded study on the infrastructural impacts of expanding OCS oil and gas activities in south Lafourche Parish*, An Analysis of Louisiana Highway 1 in Relation to Expanding Oil and Gas Activities in the Central Gulf of Mexico*, indicate that the levels of service provided by LA Hwy 1 will decline significantly through time (Guo et al., 2001). The study estimated a 3-6 percent growth in daily vehicle traffic along LA Hwy 1. Actual 2000 growth was 24 percent; more than 1,000 OCS supply and equipment trucks travel LA Hwy 1 to the port each day. The average national growth in daily vehicle traffic is 2-5 percent. In addition to servicing the OCS, LA Hwy 1 serves as an evacuation and oil-spill response route for offshore spills. In the event of an impending storm, more than 3,000 offshore workers, 1,000 port personnel, and 5,000 citizens from Grand Isle and Leeville (south of the bridge) must evacuate the area by LA Hwy 1. Offshore companies also take valuable equipment, such as bagged drilling fluids, off offshore rigs and bring it to safety inland. This increases the truck traffic along LA Hwy 1 during the evacuation process. Furthermore, statistics from the Louisiana Department of Transportation and Development (DOTD) reveal LA Hwy 1 is twice as deadly as any similar class highway in the state. The number of fatalities on LA Hwy 1 has increased directly with the growth of the OCS and, therefore, the port.

The south Lafourche Parish study concluded that deterioration of LA Hwy 1 will be exacerbated with expanding oil and gas activities, particularly those in deep water. The size and complexity of these deepwater projects, along with the limited number of service bases capable of handling their unique needs, and the addition of the C-Ports at Port Fourchon, will likely result in continued stresses on port infrastructure and associated stresses placed on the local infrastructure, especially LA Hwy 1 and the parish's water supply (Guo et al., 2001).

Exacerbating the traffic problems on LA Hwy 1 are delays caused by the six bridge openings necessary to accommodate barge traffic on Bayou Lafourche. Fifty percent of all oil and gas materials brought to Port Fourchon is barged. On average, each bridge is opened 16 times a day resulting in bottlenecks, increased accidents, and a lower quality of life. Part of the increased barge traffic is from shipping an average of 500,0000 gallons of fresh water per day to the port for offshore activities. Deepwater expansion has significantly increased the demand for water, taxing the local freshwater district. Port Fourchon uses 30 percent of the local water supply, but comprises only 1 percent of the serving population.

The demand for OCS-related labor in the area has resulted in the presence of in-migration. This temporary importation of labor, particularly in south Lafourche, is a unique situation exacerbated by the shadow effect. The unusual work schedules in the oil and gas extraction industry also supports employment outside the analysis area because long-distance commuting can be reasonably accomplished on such an infrequent basis. So, while employment opportunities are growing in the oil and gas extraction and supporting industries within the Gulf of Mexico analysis area, some of that employment has been met from outside the area. This has resulted in net positive migration in some focal point locales and has caused a scarcity of housing, a shortage of municipal personnel (i.e., policemen, firemen, engineers, etc.), stresses on the capabilities of available infrastructure, and an increase in the cost of living. Chouest, which owns C-Port and C-Port 2 in Port Fourchon, North American Shipbuilding in Larose, Louisiana, and North American Fabricators in Houma, Louisiana, have experienced these impacts first hand. Unable to find housing for their workers, Chouest built an apartment complex for the workers they had to recruit from outside of Louisiana because of the labor and skills shortage within the State.

The extensive deterioration of LA Hwy 1 is mostly due to coastal landloss from wave forces; LA Hwy 1 divides the Barataria and Terrebonne estuaries, the Nation's two most productive estuaries. Port Fourchon has been active in building up the embankment with channel dredging materials, but it is a short-term fix to a long-term problem that grows worse every day. At present, Golden Meadow, Louisiana, to Larose, Louisiana, is the only section of the highway that is four lanes. While the State and local government have received revenue from the increased OCS activity at Port Fourchon, the cost of impacts from OCS operations have exceeded growth in the revenue stream. At present, the Louisiana Department of Transportation and Development (DOTD), which manages LA Hwy 1, and Port Fourchon are completing a draft EIS on a new four-lane highway. Funding is estimated at $650 million. The port and community leaders realize that efforts such as the Conservation and Reinvestment Act (CARA) will be vital in mitigating OCS impacts, but it will not completely cover the cost of a new highway. Monies from the Act are to be used for all offshore oil and gas impacts; consequently, only a portion can go to infrastructure projects.

In the EA prepared for Lease Sale 182, MMS recognized Port Fourchon and LA Hwy 1's importance to the nation's energy infrastructure and emphasized its desire for impact assistance to ameliorate effects of the OCS Program. As the port has grown, its importance to the nation's energy infrastructure has increased significantly. Twenty percent of the Nation's oil and 25-27 percent of the natural gas are located offshore Louisiana. The port services 90 percent of the Gulf's deepwater activity. In addition, as of September 5, 2001, Port Fourchon is servicing about 39 percent of all offshore mobile rigs working in the Gulf of Mexico OCS. Of this total, nearly 59 percent are located in deepwater (One Offshore, 2001a). Furthermore, LOOP is connected to 30 percent of the U.S.'s refineries. With the increasing importance of deepwater development and the potential for FPSO's working in the Gulf of Mexico in the near future, LOOP will become even more important to the U.S. energy intermodal system and, therefore, so will Port Fourchon.

LA Hwy 1 has also been recognized on the national level. In 1995 LA Hwy 1 was selected as part of the National Highway System (NHS) because of its intermodal link to this nation's energy supply. The NHS Act designates roads that are critical for the economy, defense, and mobility of the nation. In December 2001, Congress designated LA Hwy 1 as one of only 44 high priority corridors in the U.S. based on its significance to the nation's energy infrastructure.

Several other service bases have also seen a large increase in OCS-related activity and concomitant stresses placed on their local infrastructure. These ports include Cameron, Venice, and Morgan City, Louisiana, which are servicing 18 percent, 15 percent, and 10 percent of OCS-related offshore mobile rig activity, respectively (One Offshore, 2001a). The limited number of service bases capable of servicing deepwater activities suggests that stresses placed on local infrastructure at these bases will continue to the extent that deepwater tracts are leased, explored, and developed. Recent leasing history has shown an increase in deepwater interest.

3.3.3.3. Current Economic Baseline Data

Oil and natural gas prices are used to evaluate the oil and gas industry's ability to economically develop resources. Current crude oil and natural gas prices are substantially above the economically viable threshold for drilling in the Gulf of Mexico. As of October 4, 2001, Henry Hub Natural Gas closed at $2.414 per million BTU (a decrease of 3.5% or $0.086 from a month ago) (Oilnergy, 2001). During September 2001, natural gas futures plummeted below $2 per thousand cubic feet for the first time since April 1999 amid concerns that the U.S. economy may enter a recession. Natural gas demand from manufacturers, which accounts for about a quarter of U.S. consumption, is down and a turnaround in the economy is not expected in the short term (Houston Chronicle On-line, 2001a). Although the Secretary-General of OPEC, Ali Rodriguez, said that the Arab-dominated cartel would ensure world oil supplies and price stability immediately following the September 11, 2001, terrorist attacks on the United States, oil and gold prices surged (COMTEX, 2001). Crude oil prices then dropped, taking their biggest hit in 10 years during September 2001. Fear of a recession that would reduce demand is compounded by the belief that OPEC will not act to maintain prices (Houston Chronicle On-line, 2001b). Oil prices have since moved moderately higher. Market reaction has been muted because Allied strikes in response to the terrorist attacks do not threaten Middle East oil supplies (Reuters, 2001). On October 4, 2001, light sweet crude listed for $22.63 per barrel on the New York Mercantile Exchange (a decrease of 19.27% or $5.40 from a month ago).

New rig deliveries and orders are another indicator of the industry. Fifteen new rigs were delivered in 2000, three of which were speculative new builds. All three of these "spec" rigs had contracts waiting for them by the time they were delivered. After a hiatus from placing new rig orders in 1999, drilling contractors looked to increase their level of activities in 2000. Orders for six new drilling rigs were placed in 2000. A recent survey by Lehman Brothers asked over 60 "leading experts" how many rig orders would be placed for 2001. The average of all the predictions was 13 (One Offshore, 2001b). Another indicator of the direction of the industry is the exploration and development (E&D) expenditures of the major oil and gas companies. After substantially cutting their E&D budgets during the 1998 and 1999 fiscal years, majors are once again increasing activity levels. Lehman Brothers' semi-annual Original E&P Spending Survey predicts a 19.1 percent worldwide spending increase, although natural gas prices, not oil prices, were identified as the number one determinant of E&P spending in 2001 (One Offshore, 2001b).

In addition to new rig deliveries and orders, drilling rig use is employed by the industry as a barometer of economic activity. After having hovered around 90 percent or better for most of 2000, the September 2001 utilization rate for all marketed mobile rigs in the Gulf of Mexico was 62.7 percent (One Offshore, 2001a). This breaks down as a 56.7 percent utilization rate for jackups (average day rates of \$20,000-66,000); 76.7 percent for semisubmersibles (average day rates of \$30,000-175,000); 100 percent for drillships (average day rates of \$125,000-150,000); and 57.1 percent for submersibles (average day rates of about \$22,500). Platform rigs in the Gulf recorded a 58.8 percent utilization rate, while inland barges had a 71.2 percent utilization rate. The decline in the Gulf of Mexico rig market utilization is the result of a weakening demand brought on the slide in U.S. natural gas prices in 2001-2002. Most of the weakness in the market continues to remain in the jackup fleet. Gulf jackup utilization now stands at 56.7 percent, off 3.3 percentage points from the previous week. The soft conditions the region is experiencing are likely to continue into the first quarter of next year (One Offshore, 2001a).

As rig utilization rates have fallen and the market has become much softer, drilling contractors are no longer in search of skilled crews to run their rigs. While some contractors are recruiting full speed ahead, some are only recruiting for deepwater vessels, while others are not recruiting at all or only at the entry level. While some operators are still impacted from laying off too many crews during the downturn in 1998, it appears that many companies are more careful about laying off crews this time in response to a slowing market. If companies begin laying off personnel and then the market turns up again, drilling contractors may once again struggle to recruit skilled personnel (One Offshore, 2001b).

Offshore service vessel (OSV) day rates, another indicator of the industry's activity, remains strong despite the softening of the drilling rig market, which most vessel operators believe will become active later this year (Greenberg, 2001). The July 2001 average day rates for all three types of vessels used by the offshore oil and gas industry increased from the July 2000 averages. Anchor-handling tug/supply vessel (AHTS) average day rates ranged from \$10,500 for under 6,000-hp vessels to \$12,500 for over 6,000-hp vessels; utilization rates were 88 percent and 100 percent, respectively. Supply boat average day rates ranged from \$7,718 for boats up to 200 ft and \$10,950 for boats 200 ft and over; utilization was 89 percent and 100 percent, respectively. Crewboat average day rates ranged from \$2,928 for boats under 125 ft to \$3,775 for boats 125 ft and over; utilization was 100 percent and 98 percent, respectively.

Commencing with Central Gulf of Mexico Lease Sale 178 Part 1 in March 2001, new royalty relief provisions for both oil and gas production in the Gulf of Mexico's deep and shallow waters were enacted. These rules will govern the next three years of lease sales. Central Lease Sale 178 Part 1 resulted in 534 leases (an increase of 59.88% or 200 blocks from Central Lease Sale 175 in March 2000). Of these 534 leases, 348 were in shallow water (0-400 m). This increase of 67.30 percent from the last Central lease sale largely reflects the intensified interest in natural gas due to higher prices over the last year and the new royalty relief provisions. The 186 blocks receiving bids in deepwater (greater than 400 m) reflect an increase of 47.62 percent or 60 blocks. Again, this dramatic increase in leasing could be a result of the recently issued royalty relief provisions. Western Gulf of Mexico Lease Sale 180 and Central Gulf of Mexico Lease Sale 178 Part 2, offering the newly available United States' blocks beyond the U.S. Exclusive Economic Zone, were held jointly on August 22, 2001. No bids were received for blocks offered in Central Gulf Lease Sale 178 Part 2. Of the 4,114 blocks offered in Western Gulf Lease Sale 180, 320 received bids. About 55 percent of blocks receiving bids (or 177 blocks) in Western Lease Sale 180 are in deepwater.

3.3.3.4. Demographics

Tables 3-12 to 3-3-27 contain the analysis area's baseline projections for population, age, race and ethnic composition, and education over the life of the proposed actions. These tables present the projections by subarea, each Gulf of Mexico state, and the United States. Projections, through 2040, are based on the Woods and Poole Economics Inc.'s *Complete Economic and Demographic Data Source* (2001). These baseline projections assume the continuation of existing social, economic, and technological trends. Therefore the projections include population associated with the continuation of current patterns in OCS leasing activity, which encompasses the proposed actions in the CPA and WPA.

In some analysis area locales, i.e., Port Fourchon and Lockport, Louisiana, there has been an influx of workers from Mexico, India, and other parts of the U.S. because of the shortage of local workers in the local community (Keithly, 2001). While these new residents present stresses on communities' infrastructure and government services, they have only minimally changed local demographics (i.e., population, educational attainment, age, and race distribution have only changed negligibly with respect to OCS activities).

3.3.3.4.1. Population

The analysis area consists of highly populated metropolitan areas (such as the Houston MSA, which predominates Subarea TX-2) and sparsely populated rural areas (as is much of Subarea TX-1). Some communities in the analysis area experienced extensive growth during the late 1970's and early 1980's when OCS activity was booming. Following the drop in oil prices, many of these same areas experienced a loss in population (Gramling, 1984; Laska et al., 1993). All subarea populations are expected to grow at a higher rate than the United States' average annual population growth rate over the life of the proposed actions, reflecting the region to region migration pattern of favoring the south and west over the northeast and midwest (USDOC, Bureau of the Census, 2001). This is a continuation of historic trends. Average annual population growth projected over the life of the proposed actions range from a low of 0.87 percent for Subarea LA-3 (dominated by the Orleans MSA) to a high of 1.59 percent for Subarea FL-1 in the western panhandle of Florida. Over the same time period, the population for the United States is expected to grow at about 0.76 percent per year.

The population in the analysis area throughout the life of the proposed actions is expected to remain a fairly even mix of male/female, with the female population having a slight edge over the male population (particularly over time as the population ages). The population mix of the subareas is only slightly more female than that of the United States.

3.3.3.4.2. Age

The median age for the subareas in Texas, Louisiana, Mississippi, and Alabama compare favorably with the median age of the United States as a whole, with a slight tendency toward an older population moving eastward across the subareas. Nationwide there is an expected aging tendency with the percentage of the population in the 65 years and over category doubling. By 2011, the baby boomers will start to turn 65, and by the year 2025, the percentage of older people projected to live in the United States as a whole will be greater than the current percentage in Florida (AmeriStat, 2001). Over the same 40 years, all of the subareas, with the exception of Subarea FL-3, are expected to show a similar trend.

3.3.3.4.3. Race and Ethnic Composition

The racial and ethnic composition of the analysis area reflects both historical settlement patterns and current economic activities. For example, those counties in Texas where Hispanics are the dominant group – Cameron to Nueces (Brownsville to Corpus Christi) – were also settled by people from Mexico. Their descendants remain, typically working in truck farming, tending cattle, or in low-wage industrial jobs. From Aransas to Harris County (Houston), the size of the African-American populace increases, indicating more urban and diverse economic pursuits. In Jefferson County, Texas, adjacent to Louisiana, African-Americans outnumber Hispanics, reflecting the dominant minority status of African-Americans throughout the rest of the analysis area. Despite the larger number of white, non-Hispanic people in coastal Texas, Louisiana, Mississippi, and Alabama, together African-Americans and Hispanics outnumber whites, a trend which is national, not just regional, and a trend which is increasing. Compared with the United States, there is a higher non-white racial composition to the Texas, Louisiana, Mississippi, and Alabama coastal areas with the exception of Subarea TX-1. This subarea borders Mexico and has the highest concentration of Hispanic population. Southwestern Louisiana is Acadian country. Settlers included Houma Indians, French, Spanish, English, and African. (See Chapter 3.3.3.10 Environmental Justice for further discussion of minority and low-income populations.)

3.3.3.4.4. Education

At present, the 2000 U.S. Census data for education at the county/parish level have not been released. The last available data at this level is the 1990 Census data. Therefore, this analysis uses the 2000 U.S. Census Supplementary Survey Profile educational attainment data for States. For people 25 years and over, 75.2 percent of the population in the U.S. has graduated from high school, while 20.3 percent has received a bachelor's degree. Texas' educational attainment percentages are higher than the national average for both categories: 76.8 and 23.5 percent, respectively. Louisiana, while higher than the national average for high school graduates, 76.7 percent, is lower for college degrees, 19.5 percent. Mississippi's educational attainments are lower than the Nation's for both categories—74.3 and 18.6 percent, respectively. Alabama, like Louisiana, has a higher than national high school graduation rate (76.0%), but a lower rate for bachelor's degree (20.2%).

Responsibility for public education rests with each State. American College Test (ACT) scores are available for all states as well as the nation. The ACT assessment is a curriculum-based exam that measures students on what they have learned in school. Students' scores reflect the skills they possess in four academic areas – English, reading, mathematics, and science reasoning. Table 3-28 depicts average ACT scores for the states that border the Gulf of Mexico.

The School-based Administration Test (SAT) is taken primarily by college bound seniors. The SAT scores nationwide have risen significantly over the past decade. Since 1991, verbal scores have increased 7 points while math scores have increased 14 points. Table 3-29 depicts Mean SAT I Verbal and Math Scores for the Gulf of Mexico Coast States. Students also report higher academic aspirations than did students of the past. More than half of all college-bound students plan to pursue Master and/or doctoral degrees. The College Board discourages comparison of SAT scores by state.

Texas School Regions 1 through 5 roughly correspond to the Texas analysis area. Texas School Region 4 includes Houston, the international headquarters for many energy industries. Student enrollment in the public education system has slightly declined for all Texas School Regions except Region 4. Nearly 80 percent of all Texas students taking the Texas Assessment of Academic Skills (TAAS) passed all tests taken in 2000. Performance has increased by 24.3 percent over the past 6 years, with some minority groups increasing their performance by as much as 35 points. Texas students in the public school system have shown significant improvement in mathematics, increasing by almost 27 percent since 1994. Minority and economically disadvantage students have made the most impressive gains. Texas students also have shown advances in reading, as evidenced by TAAS tests, with performance increasing by 7.4 percent since 1996. These gains have been credited to the implementation of the Texas Reading Initiative in 1996. Participation in college admission testing has increased in Texas at higher rates than the nation. From 1995 to 1999, the number of SAT test takers increased 21.6 percent in Texas, compared to 14.2 percent nationwide; while the number of ACT test takers increased 8.7 percent in Texas, compared to 7.8 percent nationwide (Texas Public Education Portal, 2001). Texas students averaged an ACT composite score of 20.3 in all years from 1998 to 2001 as compared to the national average of 21.6 for all years.

In Louisiana, enrollment in parochial and other non-public school systems is sizable, particularly in the New Orleans metropolitan area. About 83 percent of nonpublic students in Louisiana are white, about 13 percent are black, and the remaining 4 percent are American Indian, Asian, or Hispanic. In the 1999-2000 school year, about $5,814/student was spent in the Louisiana public school system. Average daily attendance as a percent of public school membership in the 1999-2000 school years was 92.7 percent for Louisiana, as compared to the U.S. average of 91.29 percent. Nearly 70 percent of Louisiana's public middle and elementary schools improved their performance significantly in the past two years. A school's Louisiana Educational Assessment Program results, Iowa test results, attendance, and drop-out data measures performance. The State's average performance score has risen from 69.4 in 1999 to 81.3 in 2001. The goal is to earn a performance score of 100 by 2009, about the national average. Louisiana students averaged an ACT composite score of 19.6 in all years from 1999 to 2001, as compared to the national average of 21.6 for those years.

"The local school system in [Greater Lafourche Parish] is now facing the issues and challenges related to bilingual education as Spanish speakers [from increased OCS activities] begin to move to the area. This is often a difficult task for large metropolitan school system and the community in this case is rather small and strongly French in its background and history" (Keithly, 2001). Furthermore, this has resulted in additional costs to the school system.

Harrison, Hancock, and Jackson County School Districts are located in the Mississippi analysis area. The curriculum reflects national standards and addresses the competencies measured by high stakes testing in Mississippi. Technology is used as a tool of instruction through computer-assisted instruction and to enhance skills of search and product development. The Hancock County School District, serving about 4,200 students in grades kindergarten through twelve, has a district-wide student/teacher ratio of 23 to 1, and an average per pupil expenditure in 1997-1998 of about $5,900. The Hancock County School District is ranked in the top quarter of all Mississippi school districts. The Jackson Public School District is the largest and only urban school district in Mississippi, with a 31,235 student enrollment (94.5% minority). The District's rating from the Mississippi Commission on School Accreditation is Level 3 (successful) and every school in the district is accredited by the Southern Association of Colleges and Schools. Mississippi students averaged ACT composite scores of 18.7 in all years from 1998 to 2000 and 18.5 for the year 2001 as compared to the national average of 21.6 for all years.

Alabama has recently adopted the Equity and Adequacy Plan. The Plan increases class time and adds teachers to the classroom. It also addresses practically every area of public education, such as buildings and maintenance, teacher testing, the addition of textbooks and computers, special education, educational initiatives, and school libraries. Major changes in the current Alabama Education Foundation Program will be required to support educationally adequate initiatives, which are estimated to cost about $1.7 billion. Alabama students averaged ACT composite scores of 20.1 for years 1998 and 2001 and 20.2 for the years 1999 and 2000, as compared to the national average of 21.6 for all years.

3.3.3.5. Economic Factors

Tables 3-12 to 3-27 contain the analysis area's baseline projections for employment, business patterns, and income and wealth over the life of the proposed actions. These tables present the projections by subarea, each Gulf of Mexico state, and the Unites States. Projections through 2040 are based on the Woods and Poole's "Complete Economic and Demographic Data Source" (Woods and Poole Economics, Inc., 2001). These baseline projections assume the continuation of existing social, economic, and technological trends. Therefore, the projections include employment associated with the continuation of current patterns in OCS leasing activity, which encompasses the proposed actions in the CPA and WPA, as well as the continuation of trends in other industries important to the region. Chapter 3.3.3.1.2 discusses the analysis area's major employment sectors.

While the OCS industry may not be the dominant industry in a subarea, it can be in a specific locale within a subarea, causing that focal point to experience impacts. For example, in Port Fourchon and Lockport, Louisiana, there has been an influx of workers from Mexico, India, and other parts of the U.S. because of the shortage of local workers in the local community. While these new residents are expected to only negligibly impact the subarea's demographics, they have presented the communities with added stress to infrastructure and government services. Many of these increased costs to local governments are hard to quantify. Some locally provided services are tied to the unique needs of the oil and gas offshore industry. For example, schools, city water, law enforcement, and roads have been particularly affected by the growth of offshore development (Keithly, 2001). Furthermore, the cyclical nature of the oil and gas industry (boom/bust) makes allocating budgetary monies and personnel to these services difficult.

3.3.3.5.1. Employment

Average annual employment growth projected over the life of the proposed actions range from a low of 0.99 percent for Subarea LA-3 (predominated by the Orleans MSA) to a high of 1.92 percent for Subarea FL-1 in the western panhandle of Florida. Over the same time period, employment for the United States is expected to grow at about 1.29 percent per year, while the Gulf of Mexico analysis area is expected to grow at about 1.54 percent per year. As stated above, this represents growth in general employment for the subareas. Continuation of existing trends, both in OCS activity and other industries in the area, are included in the projections. (See Chapter 3.3.3.5 for more a more complete examination of employment and labor issues with respect to each OCS industry.)

3.3.3.5.2. Income and Wealth

Median household income in the United States was $42,148 in the year 2000. This value equaled the value for 1999 in real terms, the highest level ever recorded in the Current Population Survey. Median incomes for Hispanic (who may be of any race) and Black (African American) households hit new all-time highs of $33,447 and $30,439, respectively. The median household incomes of white non-Hispanic ($45,904) and Asian and Pacific Islander ($55,521) households equaled their highest level ever (USDOC, Bureau of the Census, 2001).

Income associated with the industrial sectors for the WPA coastal subareas and that of the CPA are similar. Because the service industry is a major employer in the analysis area, this industry contributes significantly (percentage-wise) to income. The manufacturing and construction industries also contribute greatly, in percentage terms, towards income earned for the subareas.

Using the Woods and Poole Wealth Index, all subareas within the Gulf of Mexico analysis area, with the exception of Subareas FL-3 and FL-4, rank considerably below the United States in terms of wealth. Subareas FL-3 and FL-4 rank slightly higher than the U.S. Ironically, Subarea FL-2 ranks lowest on the wealth scale of all subareas in the region. The Florida counties are the least influenced by OCS development in the analysis area. All other subareas range from the low 70's to upper 80's for their respective wealth indices throughout time, with the United States being 100. The Wealth Index is the weighted average of regional income per capita divided by U.S. income per capita (80% of the index); plus the regional proportion of income from dividends/interest/rent divided by the U.S. proportion (10% of the index); plus the U.S. proportion of income from transfers divided by the regional proportion (10% of the index). (See Chapter 3.3.3.10 Environmental Justice for further discussion of minority and low-income populations.)

3.3.3.5.3. Business Patterns by Industrial Sector

The industrial composition for the subareas in the WPA and that in the CPA are similar. With the exception of Subareas LA-2 and MA-1, the top four ranking sectors in terms of employment in the analysis area are the service, manufacturing, retail trade, and State and local government sectors. In Subareas LA-2 and MA-1, construction and State and local government, respectively, replace manufacturing as one of the top four industries on the basis of employment. The service industry employs more people in all subareas with the exception of Subarea FL-2, in which State and local government is first in terms of employment. The service industry is also the fastest growing industry.

As part of its economic impact analysis in Chapter 4, MMS uses IMPLAN's input-output model. A set of multipliers is created for each subarea in the analysis area based on each subarea's unique industry make-up described above. An assessment of the change in overall economic activity for each subarea is then modeled as a result of the expected changes in economic activity associated with holding a CPA or WPA lease sale.

3.3.3.6. Non-OCS-Related Marine Transport

An extensive maritime industry exists in the northern Gulf of Mexico. Figure 3-11 shows the major ports and domestic waterways in the analysis area, while Tables 3-30 and 3-31 present the 1999 channel depth, number of trips, and freight traffic of OCS-related waterways. Maritime traffic is either domestic or foreign. There is a substantial amount of domestic waterborne commerce in the analysis area through the Gulf Intracoastal Waterway (GIWW), which follows the coastline inshore and through bays and estuaries, and in some cases offshore. In addition to coastwise transport between Gulf of Mexico ports, foreign maritime traffic is extensive. Major trade shipping routes between Gulf ports and ports outside the northern Gulf of Mexico occur via the Bay of Campeche, the Yucatan Channel, and the Straits of Florida.

Fourteen of the 50 leading U.S. ports (based on millions of short tons in 1999) are located on the Gulf of Mexico. All five Gulf States, when ranked by state tons in 1999, are in the top 20 (1-Louisiana, 2-Texas, 5-Florida, 16-Alabama, and 20-Mississippi), reflecting the importance of the analysis area's ports to U.S. waterborne traffic. Major ports in the analysis area by port tons for 1999 include 1-South Louisiana, Louisiana; 2-Houston, Texas; 4-New Orleans, Louisiana; 5-Corpus Christi, Texas; 6-Beaumont, Texas; 7-Baton Rouge, Louisiana; and 8-Port of Plaquemines, Louisiana. The ports of Tampa, Florida; Lake Charles, Louisiana; Texas City, Texas; Mobile, Alabama; Pascagoula, Mississippi; Freeport, Texas; and Port Arthur, Texas, are also in the top 50 ports. Major inland waterways include the Gulf Intracoastal Waterway; the Houston-Galveston Ship Channel; the Sabine River; the Calcasieu River; the Atchafalaya River; the Morgan City-Port Allen Route; the Chene, Bouef, and Black Waterway; the Houma Navigation Canal; the Bayou Lafourche/West Belle Pass; the Mississippi River; the Tombigbee River; the Alabama River; and the Mobile Ship Channel (U.S. Dept. of the Army, COE, 2001a).

In terms of tonnage for all commodities, including domestic or foreign, inbound or outbound, the top six ports in 1999, in decreasing order, were the Port of South Louisiana, Sabine-Neches, Port of New

Orleans, Beaumont, Port of Baton Rouge, and Port of Plaquemines. As seen in Table 3-31, crude and petroleum products make up a large portion of total commodities transported through the analysis area's ports. Extensive refinery capacity, easy port access, and a well-developed transportation system have contributed to the development of the Gulf of Mexico coast region as an important center for handling oil to meet the world's energy needs. Both crude oil and petroleum products travel through the Gulf and these ports. Crude oil is tankard into area refineries from domestic production occurring in the Atlantic and Pacific Oceans. Crude oil produced within the Gulf of Mexico region is barged among Gulf terminals to reach refineries and onshore transportation routes. Petroleum products are barged, tankered, piped, or trucked from the large refinery complexes. Between 60 and 65 percent of the crude oil being imported into the United States comes through Gulf of Mexico waters. The area also includes the Nation's Strategic Petroleum Reserve and LOOP, the only deepwater crude-oil terminals in the country.

In 1999, there was a considerable amount of waterborne commerce along the Gulf Coast from Pensacola Bay, Florida, to the Mexican border (U.S. Dept. of the Army, COE, 2001a). Review of non-OCS-related vessel and freight traffic during 1999 (Tables 3-30 and 3-31) shows that vessel trips and waterborne commerce occurred primarily west of the mouth of the Mississippi River. More than 42 percent of the vessel trips recorded in 1999 within the Pensacola Bay to Mexican border segment of the GIWW took place between the Mississippi and Sabine Rivers. Vessel trips from Mobile Bay, Alabama, to New Orleans, Louisiana, accounted for 16 percent of total GIWW trips, while the Sabine to Galveston route and the Galveston to Corpus Christi route accounted for 21 and 15 percent, respectively. Tanker traffic was most intense between the Mississippi and Sabine Rivers.

The 1999 statistics for vessel trips in harbors, channels, and waterways located between Pensacola Bay and Sabine Pass show that there were eight major locations of vessel activity. These locations in decreasing order of activity were as follows: Port of South Louisiana, Port of New Orleans, Sabine-Neches Waterway, Port of Baton Rouge, Port of Plaquemines, Mobile Harbor, Calcasieu River and Pass, and Bayou Lafourche. The top seven waterways in terms of tanker trips during 1999 were (in decreasing order by number of tanker trips inbound and outbound trips combined), as follows: Sabine-Neches, Port of South Louisiana, Port of Baton Rouge, Port of New Orleans, Morgan City to Port Allen, Calcasieu River, and Beaumont.

The transport of crude petroleum was concentrated in four locations: Sabine-Neches, Beaumont, Port of South Louisiana, and Calcasieu River. The transport of crude petroleum was mostly imported. The four major petroleum products locations were (in descending order) Port of South Louisiana, Sabine-Neches, Port of New Orleans, and Port of Baton Rouge.

Tanker imports and exports of crude and petroleum products into the Gulf of Mexico are projected to increase (USDOE, EIA, 2001a). In 2000, approximately 2.08 BBO of crude oil (38% of U.S. total) and 1.09 BBO of petroleum products (13% of U.S. total) moved through analysis area ports. By the year 2020, these volumes are projected to grow to 2.79 BBO of crude oil and 1.77 BBO of petroleum products. Crude oil will continue to be tankered into the Gulf of Mexico for refining from Alaska, California, and the Atlantic.

3.3.3.7. OCS-Related Offshore Infrastructure

3.3.3.7.1. Offshore Platforms

Unless otherwise indicated, the following information is from the MMS study, "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

Offshore platforms play a pivotal role in the development of offshore oil and gas resources. The purpose of a platform is to house production and drilling equipment and living quarters for personnel (for manned platforms). A platform consists of two major components: an underwater part (jacket or tower) and an above water part (deck). Other platform components are living quarters, control building, and production modules. Several types of production systems are used for offshore oil and gas development in the analysis area.

A fixed platform is the most commonly used type of production system in the U.S. Gulf of Mexico. A fixed platform is a large skeletal structure extending from the bottom of the ocean to above the water level. It consists of a metal jacket, which is attached to the ocean bottom with the piles, and a deck, which accommodates drilling and production equipment and living quarters. Fixed platforms are typically installed in water depths up to 1,500 ft.

A compliant tower is similar to a fixed platform; however, the underwater section is not a jacket but a narrow, flexible tower which, due to the flexibility of its structure, can move around in the horizontal dimension, thereby withstanding significant wave and wind impact. Compliant towers are typically installed in water depth from 1,000 to 2,000 ft.

Tension and mini-tension leg platforms do not have skeletal structures extending all the way to the ocean floor. Instead, they consist of floating structures, which are kept in place by steel tendons attached to the ocean floor. Tension leg platforms can be used in different depth ranges, up to 4,000 ft.

A spar platform consists of a large vertical hull, which is moored to the ocean floor with up to 20 lines. On top of the hull sits the deck with production equipment and living quarters. At present, SPAR platforms are used in water depth up to 3,000 ft; however, SPAR technology allows installations in waters as deep as 7,500 ft.

A floating production system consists of a semi-submersible unit that is kept stationary either by anchoring with wire ropes and chains or by the use of rotating thrusters, which self propel the semi-submersible unit. Floating production systems are suited for deepwater production in depths up to 7,500 ft.

A subsea system consists of a single subsea well or several wells producing either to a nearby platform or to a distant production facility through a pipeline and manifold systems. At present, subsea systems are used in water depths exceeding 5,000 ft.

A floating production, storage, and offloading (FPSO) system consists of a large vessel that houses production equipment. It collects oil from several sub-sea wells, stores it, and periodically offloads it to a shuttle tanker. The FPSO systems are particularly useful in development of remote oil fields where pipeline infrastructure is not available. To date, MMS has received no proposals for use of FPSO systems in the Gulf of Mexico.

Platforms are fabricated onshore and then towed to an offshore location for installation. Facilities where platforms are fabricated are called platform fabrication yards. Production operations at fabrication yards include the cutting and welding of steel components and the construction of living quarters and other structures, as well as the assembly of platform components. Fixed platform fabrication can be subdivided into two major tasks: jacket fabrication and deck fabrication.

The jacket is constructed by welding together steel plates and tubes to form a tower-like skeletal structure. Because the height of a jacket is several hundred feet, jackets are made lying horizontally on skid runners. Once the jacket is completed, it is pulled over, maintaining the same horizontal position, to a barge that transports it to an offshore location where the jacket is installed. Along with the jacket is the construction of smaller ancillary structures such as pile guides, boat landings, walkways, buoyancy tanks, handrails, etc. These structures are attached to the jacket while it is still in a horizontal position.

The deck is fabricated separately from the jacket. A typical deck is a flat platform supported by several vertical columns (deck legs). The deck provides the necessary surface to place production equipment, living quarters, and various storage facilities. Once the deck fabrication is completed, it is loaded onto a barge and transported to the site of the platform, where it is lifted by derrick barges and attached to the already installed jacket.

Tables in Chapter 9.1.5 present information on platforms operating in the OCS.

3.3.3.7.2. Offshore Transport

Service Vessels

Unless otherwise indicated, the following information is from "The Gulf of Mexico Supply Vessel Industry, A Return to the Crossroads" (Simmons & Company International, 2000).

Service vessels are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. In addition to offshore personnel, service vessels carry cargo (i.e., freshwater, fuel, cement, barite, liquid drilling fluids, tubulars, equipment, and food) offshore. There are currently 376 supply vessels (platform supply vessels (PSV's) and anchor handling tugs/supply vessels (AHTS)) in the Gulf of Mexico analysis area (up from a 1993 low of 247 units). One hundred and sixteen (or 35%) of the 376 supply vessels were built since 1996. This breaks down as 83 PSV's, 15 AHTS, and 18 units for specialty services. The first newbuilds commenced construction in late 1996 when dayrates were in the $6,000-7,000 range and utilization was steady at 95 percent; a primary driver of supply vessel demand is rig activity. The first deliveries were in early 1997. As dayrates continued to accelerate during 1997, reaching the $8,000-9,000 range, more orders were placed. With an average delivery time of 12-16 months (and an average cost of $8-10 million), most newbuilds entered the market during the second half of 1998 and 1999, just as the Asian crisis and falling oil prices began to take hold, leading to demand, utilization, and dayrates ($2,400) falling dramatically.

Although the traditional workhorse of the Gulf of Mexico has been the standard 180-ft supply vessel, none of the boats built were less than 190 ft in length. Eighty-seven percent of the newbuilds were 200 ft in length or greater while over half were 220 ft in length or greater. The increasing size of the newbuild fleet is directly related to the emergence of deepwater drilling in the Gulf of Mexico over the past four years. At present, nearly three-quarters of the supply fleet in the analysis area is less than 200 ft long and work primarily in the shallow waters; 28 percent of the fleet is 200 ft or larger and works primarily in deepwater. Although length is typically used to describe supply vessels, it is actually the liquid mud capacity and dynamic positioning capability that are the most important criteria for deepwater operators. Most operators view 220-ft boats as the minimum for work in supporting drilling operations. Typical Gulf of Mexico vessel specifications are shown in Table 3-32. The Gulf of Mexico supply boat industry does not have a young fleet. Nearly 40 percent of the entire fleet is at least 20 years old. Only 26 percent of the fleet is 10 years old or younger. The average age of the fleet in 1997 was 17.9 years. At present, the average age is 15.7 years, reflecting the newbuild expansion of the last cycle. The estimated life of a service vessel is 25 years.

Since the last industry downturn that began in 1998, the supply boat market has experienced a great deal of consolidation. During the last two years, numerous smaller players exited the industry via bankruptcy, asset sales to larger competitors, or asset sales to outside the industry. More than half of the smaller boat operators that operated three or fewer boats in the last cycle are no longer in the business. The resulting Gulf of Mexico supply boat industry is very fragmented. There are 24 boat operators in the analysis area. Sixteen of these operators own fleets of less than 10 boats. Nine own three boats are less. Of the 24 operators, 6 are public and 18 are privately held. The six public companies (Trico Marine, 13%; Ensco Marine, 7%; Seacor Smith, 7%; Sea Mar, 7%; and Seabulk Offshore, 6%) control 70 percent of the total fleet. Edison Chouest is the largest private boat operator with 11 percent of the total supply-vessel fleet. Chouest was the first company to undertake major newbuilding projects and was the most significant builder in the last cycle with respect to the number of units (49) and total capital invested ($677 million). Over 8 percent of the 220-ft newbuilds were Edison Chouest vessels. The modern, high-capacity fleet has given Chouest a strong presence in deepwater. The second most active newbuild participant was Seacor, which spent over $222.5 million on 14 vessels. The market share for several major companies has experienced significant changes. The most noticeable change is the decline in Tidewater's market share from 42 percent in 1997 to 30 percent in 2000. This decline is a result of Tidewater's restraint from building in the last cycle, although Tidewater has recently announced that it has committed up to $300 million to a program that will bring 21 crew and fast crew/supply vessels into its fleet by the year 2003. Chouest almost doubled their market share over the last three years through their aggressive newbuild program.

The emergence of deepwater drilling has become the most important factor going forward in the Gulf of Mexico supply boat industry. As a result of newbuilds and conversions, the number of drilling rigs capable of drilling in over 3,000 ft of water has quadrupled sine 1996. Compared to the shallow waters of the Gulf of Mexico, deepwater drilling support requires a significantly enhanced supply boat. In deepwater more drilling mud is required to fill wellbore and risers. Thus, deepwater supply vessels need large liquid mud capacities. Deepwater drilling rigs generally operated farther from shore than conventional shallow-water units. Weather patterns can be violent, and the sea conditions are typically rougher. Therefore, in order for a supply vessel to safely maintain its position near a deepwater rig, dynamic positioning (DP) is required. With DP capability, a supply vessel uses global positioning satellites to determine an exact location and small engines or thrusters to maintain the boat's position.

Given the relative youth of the Gulf of Mexico deepwater industry, exploration and production (E&P) operating practices have not been standardized. Some E&P companies have chosen to employ two boats of the 200- to 205-ft class for support of a deepwater drilling rig. This allows the operator to shuttle boats between the rig and port, while still having a boat on location at all times. If additional items are required that are not at the rig location, the boat in port can bring the items to the rig on its next trip, effectively reducing the time needed to get supplies had only one large boat been contracted. It generally takes supply vessels 10-15 hours (one way) to get to deepwater locations compared to only a few hours for wells drilling on the shelf. While some E&P operators are using two vessels, it appears that most are moving toward the use of one larger boat (220+ ft) to support activities. Industry is increasingly using the 200-205 ft class in shallower waters. This obviously has implications for the 180-ft supply boat category.

Several E&P companies in the analysis area are currently undertaking the concept of boat pooling. Rather than assigning specific boats to specific rigs, E&P companies are experimenting with the use of several boats for a pool of rigs. Some operators will share their contracted boats with other E&P companies, while others are utilizing boat pooling specifically for their own rigs. Initial indications are that E&P companies have been successful in reducing their boat usage. Along the same vein, there is a growing interest among E&P customers toward the issue of logistics as a way to improve efficiency and reduce costs. The larger boats that have been added by the industry have the capacity and capability to serve multiple rigs on one trip from port. This is a critical factor in the logistics business. Edison Chouest recently introduced a logistics company, C-Logistics. Their first customer, Shell, was able to generate higher boat utilization and lower costs. ASCo Group and Baker Energy are also establishing logistics products.

Helicopters

Helicopters are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. Helicopters are routinely used for normal crew changes and at other times to transport management and special service personnel to offshore exploration and production sites. In addition, equipment and supplies are sometimes transported. For small parts needed for an emergency repair or for a costly piece of equipment, it is more economical to get it to and from offshore fast rather than by supply boat. Normal offshore work schedules involve two-week (or longer) periods with some crew changes on a weekly basis; therefore, helicopters will travel to some facilities at least once a week. According to the Helicopter Safety Advisory Conference (Osborne, 2000), the number of helicopter trips in support of Gulfwide OCS operations have been increasing steadily since 1994 to over 1.7 million trips annually, carrying 3.7 million passengers during 417,000 flight hours.

The Federal Aviation Administration (FAA) regulates helicopter flight patterns. Because of noise concerns, FAA Circular 91-36C encourages pilots to maintain higher than minimum altitudes near noise-sensitive areas. Corporate policy (for all helicopter companies) states that helicopters should maintain a minimum altitude of 700 ft while in transit offshore and 500 ft while working between platforms and drilling rigs. When flying over land, the specified minimum altitude is 1,000 ft over unpopulated areas and coastlines, and 2,000 ft over populated areas and sensitive areas including national parks, recreational seashores, and wildlife refuges. In addition, the guidelines and regulations promulgated by NOAA Fisheries require helicopter pilots to maintain 1,000 ft of airspace over marine mammals.

Deepwater drilling farther offshore is the growth area for helicopters. The offshore helicopter industry is purchasing new helicopters to meet the demands of deepwater: travel farther and faster, carry more personnel, all-weather capability, and lower operating costs. The helicopters in service today have travel ranges up to 450 nmi, can attain speeds over 200 mph, can carry up to 20 passengers, and may cost $10 million or more. Bell Helicopter Textron is the leading manufacturer of helicopters in the world. Other major manufacturers include Eurocopter, MD Helicopters, Sikorsky, and Agusta Westland.

Many of the platforms offshore Texas, Louisiana, Mississippi, and Alabama serve as helicopter refueling stations. At present, aircraft fuel is barged to these offshore refueling stations. While there are offshore fueling sites, it saves the industry time and money not to stop. Transportation is one of the exploration and production industry's top three costs. The newer helicopters operating in the Gulf of Mexico, though, have the range and capacity to fly without stopping to refuel, but they are more costly to operate.

Since the tasks the offshore helicopter industry provides are the same tasks supply vessels provide, they are competition for one another. While exploration and production companies like helicopters, the industry is outsourcing more and more operations to oilfield support companies, such as Baker Hughes, who are much more cost conscious and skeptical about the high cost of helicopters. Fast boats are beginning to erode the helicopter industry's share of the offshore transportation business, particularly in shallow water. Another consideration for the helicopter industry is new technology such as subsea systems. As discussed in Chapter 4.1.1.3, a subsea system consists of a single subsea well or several wells producing either to a nearby platform or to a distant production facility through pipeline and manifold systems. These systems decrease the number of platforms and personnel needed offshore, therefore reducing the amount of transportation needed.

3.3.3.8. OCS-Related Coastal Infrastructure

Unless otherwise indicated, the following information is from the MMS study, "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

The OCS development is supported by a large onshore infrastructure industry consisting of thousands of small and large contractors responsible for virtually every facet of the activity, including supply, maintenance, and crew bases. These contractors are hired by major and independent companies alike to service production areas, provide material and manpower support, and to repair and maintain facilities along the coasts. The offshore support industry employs thousands of workers and is responsible for billions of dollars in economic activity in the analysis area. Virtually all of these support industries are found adjacent to ports.

Throughout the last 50 years the fabrication industry in the analysis area has been the cornerstone for the offshore oil and gas industry. There are hundreds of onshore facilities in the analysis area that support the offshore industry. The fabrication corridor stretches approximately 1,000 mi from the Texas/Mexico border to Alabama. Other offshore support industries are responsible for such products and services as engine and turbine construction and repair, electric generators, chains, gears, tools, pumps, compressors, and a variety of other tools. Additionally, drilling muds, chemicals, and fluids are produced and transported from onshore support facilities. Many types of transportation vessels and helicopters are used to transport workers and materials to and from OCS platforms. As technology matures, additional support industries will evolve.

With the expanding interest in deepwater activities, many onshore facilities have migrated somewhat to areas that have capabilities of handling deepwater vessels, which require more draft. Since fewer ports have such access, dredging operations at existing facilities or contractor expansion to areas that can handle such vessels has occurred. This has also led to heated competition between port facilities. Many support industries have multiple locations among the key port facilities. For instance, Bollinger Shipyards has locations in Texas City, Galveston, Calcasieu, Morgan City, Houma, Lockport, and Fourchon, as well as many other locations.

Shipbuilding and repair facilities are located in key ports along the Gulf of Mexico coast. A typical shipbuilding facility consists of a variety of structures, including maintenance and repair facilities. These yards are typically found adjacent to a deep ship channel that allows them to serve deepwater vessels. Additionally, these facilities also serve other commercial and military needs in order to diversify and protect themselves against leaner oil industry times.

Pipelaying and burial contractors are also found near port facilities. Though there has been a consolidation of sorts, at least five companies account for almost 90 percent of the total footage laid as recently as 1999, resulting in sufficient competition. As offshore production enters deeper water, it requires contractors to retool because thicker-walled pipe is required to withstand the pressures exerted at such depths. This has also led to an evolution of sorts for pipelaying vessels.

Other support facilities are located near ports, including warehouses for chemicals, muds, tools, and other equipment. Crew quarters and bases are also near ports, but some helicopter facilities are located farther inland. Transportation to and from offshore rigs is a major expense for producers, and many transportation companies exist to provide this service. Often one or two supply ships and at least one helicopter is used to support each platform.

In the exploration and development stage, the majority of costs are associated with exploration (19.2%), drilling (16.1%), steel pipe (10.3%), specialized machinery (7.1%), chemicals (6.9%), and water transport (6.7%). The majority of expenses in the pipelaying segment are associated with construction (52.8%) and steel pipe (26%), while the largest expenses associated with the platform operations include instrumentation (44.3%), pipeline construction (15.9%), specialized machinery (13.7%), and pumps and compressors (10.2%). In the ongoing operation and maintenance stage, the largest expenses are associated with operations (36.3%), followed by other services (18.4%) and environmental engineering services (14.7%). The percentage of expenses associated with each of these areas is indicative of the size of the supporting industries.

Like onshore development, OCS exploration and production is driven by oil and gas prices. The 1986 collapse of oil prices forced many offshore companies to close their doors, while the remaining companies often consolidated and expanded operations to include commercial and military business. This was true throughout the entire supporting industry infrastructure.

During slow times all areas feel the effects. Fewer rigs are built and maintained, fewer boats are needed, fewer chemicals are manufactured and purchased, and much less research and development (R&D) is conducted. Perhaps the most detrimental result of a downturn is the flight of many experienced personnel. This has led to severe problems for an industry closely tied to the price volatility of oil and natural gas. When experienced workers leave it is very difficult to entice them back to an industry that is so volatile.

One of the results of fewer R&D dollars is that producers, who are saddled with billion dollar projects, are forced to push much of the R&D expenditures for new technologies onto their suppliers. For example, it is common to see many suppliers shoulder the burden of seismic surveys today. Unfortunately, no single company can adequately fund and support such activities. It is important to realize that new technologies have led to the development of unrecognized, unreachable or uneconomic reserves, which often lead to significant work for the onshore support industry.

Following the massive shift in the industry in the mid-1980's, subsequent price downturns have not been as decimating to the industry, though the 1998-1999 price drop did force companies to lay off employees and to close a few facilities. Drilling declined significantly but did not cause the massive contractor flight evidenced in the mid-1980's. During this downturn, activity shifted somewhat to platform removal, maintenance, renovations, and rig surveys. Some fabrication yards diversified in order to keep their doors open, often taking in non-oil-related work such as barge repair and even military work.

The move into deepwater has increased activity and has led to a significant transformation for some contractors. Since ports with sufficient draft to accommodate deepwater-servicing equipment are limited; onshore effects appear to be concentrated in a few communities. This contrasts with earlier, nearer-shore developments that are supported by many ports and coastal communities.

3.3.3.8.1. Service Bases

Unless otherwise indicated, the following information is from the 2001 MMS study, "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

A service base is a community of businesses that load, store, and supply equipment, supplies, and personnel that are needed at offshore work sites. Although a service base may primarily serve the OCS planning area and subarea in which it is located, it may also provide significant services for the other OCS planning areas and subareas.

The oil and gas industry has thrived in the Gulf of Mexico. With the industry has come a logistical support system that links all phases of the operation and extends beyond the local community. Land-based supply and fabrication centers provide the equipment, personnel, and supplies necessary for the industry to function through intermodal connections at the Gulf of Mexico coast ports. The necessary onshore support segment includes inland transportation to supply bases, equipment manufacturing, and fabrication. The offshore support involves both waterborne and airborne transportation modes.

States along the Gulf of Mexico provide substantial amounts of support to service the oil and gas industry that is so active on the OCS. Many ports offer a variety of services and support activities to assist the industry in its ventures. Personnel, supplies, and equipment must come from the land-based support industry. All of those services must pass through a port to reach the drilling site. Table 3-33 shows the 50 service bases currently used for the OCS. These facilities were assessed from the MMS Platform Plans' primary service base designation. As can be seen from the Table 3-33, 33 of the service bases (or 66%) are located in the CPA. Of these, 29 reside in Louisiana. In addition to servicing the offshore, several of the services bases are commercially oriented ports: Mobile, Alabama; Pascagoula, Mississippi; Lake Charles, Morgan City, and Port of Plaquemines/Venice, Louisiana; and Corpus Christi, Freeport, Galveston, and Port Arthur, Texas. These activities were discussed in Chapter 3.3.3.6. The other service bases are a combination of local recreation and offshore service activity.

Based on numbers provided by Offshore Data Services, the ports of Cameron, Fourchon, Morgan City, and Venice, Louisiana, service over 81 percent of all Gulf of Mexico mobile rigs and over 91 percent of all deepwater rigs (One Offshore, 2001a). With respect to shallow-water platforms, Pascagoula, Mississippi, and Theodore, Alabama, service the EPA platforms; Cameron, Fourchon, Intracoastal City, and Morgan City, Louisiana, service 55 percent of the CPA platform; and Cameron, Louisiana, and Freeport, Galveston, and Port O'Connor, Texas, service 68 percent of the WPA shallow-water platforms. Fourchon, Morgan City, and Venice, Louisiana, service 84 percent of the CPA deepwater platforms. Freeport, Texas, and Fourchon and Morgan City, Louisiana, service 69 percent of the deepwater platforms in the WPA. While some service bases focus primarily on supplies, others focus on transportation.

This extensive network of supply ports includes a wide variety of shore-side operations from intermodal transfer to manufacturing. Their distinguishing features show great variation in size, ownership, and functional characteristics. Basically, two types of ports provide this supply base. Private ports operate as dedicated terminals to support the operation of an individual company. They often integrate both fabrication and offshore transport into their activities. Public ports lease space to individual business ventures and derive benefit through leases, fees charged, and jobs created. These benefits spread throughout the entire area and are viewed as economic development impacts. Thus, the public ports play a dual role by functioning as offshore supply points and as industrial or economic development districts. An efficient network of ports lowers costs associated with oil and gas production and significantly boosts the well-being of citizens of the adjacent communities.

The significant prosperity that has followed the industry has resulted in issues and concerns that must be addressed at the local community level. For example, additional commercial traffic associated with offshore supplies has caused worsening road conditions at Port Fourchon. While local governments near the service bases have gained revenue from the increased activity within their jurisdictions, the demands for additional services and facilities resulting from oil and gas operations have exceeded growth in the revenue stream. Local tax dollars cannot meet the demand for so many improvements in such a short time. State and Federal matching funds are sought where possible, but the acquisition of those funds often has built-in delaying factors. Nevertheless, communities are attempting to meet the demands of the offshore industry. Thus, the oil and gas industry is determining the direction and scope of improvements being made at local levels. Communities, just like the ports, must be able to anticipate future demands for their services. In order to plan for this growth, communities need timely information about trends in the industry.

Rapidly developing offshore technology has placed an additional burden on service-base ports. As OCS operations have progressively moved into deeper waters, larger vessels with deeper drafts have been phased into service, mainly for their greater range of travel, greater speed of travel, and larger carrying capacity. Services bases with the greatest appeal for deepwater activity have several common characteristics: a strong and reliable transportation system; adequate depth and width of navigation channels; adequate port facilities; existing petroleum industry support infrastructure; a location central to OCS deepwater activities; adequate worker population within commuting distance; and an insightful strong leadership. Typically, deeper draft service vessels require channels with depths of 6-8 m.

Edison Chouest, in 1996, built their C-Port facility in Fourchon, Louisiana, as a one-stop shopping service base for the offshore. This facility was described in Chapter 3.3.3.2. The success of the C-Port caused Port Fourchon to emerge as the deepwater service-base port for the OCS. In September 2001 the Corps of Engineers deepened Bayou Lafourche at Port Fourchon to accommodate the larger supply vessels. To service the WPA and northern Mexico, Chouest has started constructing a C-Port in Galveston, Texas. Services at the new Texas C-Port should commence at the end of 2002 or the beginning of 2003. In order to service the EPA, Chouest has started scouting sites for a C-Port in either Pascagoula, Mississippi, or Mobile/Theodore, Alabama. Construction on this facility will depend on successful exploration in the EPA. Based on Edison Chouest's C-Port locations and the trend for the industry to consolidate, Port Fourchon, Galveston, and either Pascagoula or Mobile/Theodore will serve as the primary deepwater service-base ports for the OCS.

The following are profiles of three ports that are significantly involved in offshore support. These profiles are representative of OCS supply/crew bases. An effort has been made to describe their operational structure as well as to describe their facilities and equipment. However, to continue to offer a viable service and to stay current with technological trends and industry standards, ports must be able to incorporate offshore oil and gas trends into their planning for future infrastructure development, staffing needs, and other impacts associated with rapid industrial growth.

Morgan City, Louisiana

The Port of Morgan City is located within the community of Morgan City in St. Mary Parish, Louisiana. With immediate access to I-49, it is one hour away from New Orleans, Lafayette, and Baton Rouge. Two thousand linear feet of rail spur and 1,500 linear feet of sidings connect the port warehouses with Burlington Northern mainline. Daily rail service is provided by Burlington Northern. The port was created in 1952. Since 1957, it has been active in both domestic and international trade. It is governed by a nine-member Board of Commissioners, who are appointed by the Governor and serve for a nine-year term. Morgan City is the only medium draft harbor between New Orleans and Houston on the Gulf. Its 400-ft wide channel is maintained by the U.S. Army Corps of Engineers to a constant depth of 20 ft. Its docking and cargo handling facilities serve a wide variety of medium draft vessels.

Centrally located along the Gulf Coast, the port is only 18 mi from the open waters of the Gulf of Mexico at the intersection of the Gulf Intracoastal Waterway (GIWW) and the Atchafalaya River. It is on the east bank of the Atchafalaya River in a natural wide and deep harbor known as Berwick Bay. The Atchafalaya River, the GIWW, and Bayous Boeuf, Black, and Chene are the connections to traffic throughout the continental United States and abroad. The Atchafalaya River has its beginnings at the junction of Old River and the Red River in east-central Louisiana. Old River is a short connection between the head of the Atchafalaya and the Mississippi Rivers. The Atchafalaya River flows southward a distance of 135 mi and empties into the Atchafalaya Bay. Traffic between points in the southwest United States and the Upper Mississippi River Valley saves approximately 342 mi per round trip by using the Atchafalaya River rather than the alternate link of the GIWW via the Harvey Locks at New Orleans.

The port is suitable to handle container, general, and bulk cargo. There are over 200 private dock facilities located in the Morgan City vicinity, most of which are oil and gas related. These facilities have heavy-lift, barge-mounted cranes with capacities to 5,000 tons, track cranes to 300 tons, and mobile cranes to 150 tons. Facilities include a 500-ft dock with a 300-ft extension, a 20,000ft^2 warehouse with rail access, a large marshalling yard, a 50 ton capacity mobile track crane, 3 forklifts, a 35-ton cherry picker, and a rail spur. In addition to 3.75 ac of on-dock storage, about 12 ac of auxiliary yard storage is available. Bulk cargo loading/unloading from/to barge and from/to yard from trucks and rail is also offered.

The port plans to expand facilities with a 30,000-lb forklift, 3 yard jockeys, 6 flat-bed trailers, and 6 chassis trailers. The Board of Commissioners is also working with the U.S. Army Corps of Engineers to determine if there is justification for dredging the channel to 35 ft. McDermott, who uses the channel, can not compete with foreign companies to manufacture the larger platforms required by deepwater because of the lack of channel depth necessary to transport the platforms to open waters.

Port Fourchon, Louisiana

Port Fourchon, Louisiana, is located at the mouth of Bayou Lafourche where it empties into the Gulf of Mexico. It is approximately 60 mi south of New Orleans. Its easy accessibility from any area in the Gulf of Mexico has made it one of the most active oil and gas ports on the coast. Port Fourchon’s location at the end of Louisiana Highway 1 is in the center of one of the richest and most rapidly developing industrial areas of the Gulf region. While the growth of other ports has slowed, Port Fourchon has been expanding to meet the changing needs of the offshore oil-field industry. Port Fourchon has been designated as one of Louisiana's Enterprise Zones and therefore offers many tax advantages. Its close proximity to the Gulf of Mexico, along with its planned development and multidimensional services, make Port Fourchon one of the most significant oil and gas ports on the Gulf Coast.

The development and supervision of Port Fourchon is under the authority of the Board of Commissioners of the Greater Lafourche Port Commission (GLPC) with headquarters in Galliano, Louisiana. The Commission is composed of nine members who are elected to serve six year terms. Established in 1960, the GLPC Board is the only elected port authority in Louisiana and its members must be at least 21 years of age and residents of the 10th Ward of Lafourche Parish, Louisiana. The Commission regulates commerce and vessel traffic within the Port Fourchon area, owns land and lease facilities, establishes 24-hr law enforcement through its Harbor Police Division, maintains paved roads and provides facilities for governmental coordination such as the U.S. Customs Service and U.S. Coast Guard. Over its 40-year history, the GLPC has cultivated opportunities for businesses and steady economic growth for Port Fourchon and the surrounding area.

Port Fourchon is a multiuse port primarily servicing the needs of oil and gas development. Other uses include commercial fishing, recreation, and shipping as well as serving as the land base for the Louisiana Offshore Port Authority (LOOP). Today, the port is comprised of approximately 600 ac and has nearly 25,000 ft of waterfront facilities. The port has grown at a phenomenal rate due to the growth in the oil and gas industry and its development in the deepwater areas of the Gulf of Mexico. In 1999 there were 124 businesses located at the port and they were increasing by one per month.

The port is connected to the GIWW via Bayou Lafourche, the Houma Navigation Canal, and the Barataria Waterway. The port's channel is 26 ft deep, enabling it to accommodate the larger supply vessels. The port also houses a large number of docks with crane service, loading/unloading equipment, warehouses, refrigerated warehouse, and numerous storage yards. Improved and unimproved property is available.

Planned expansions at the port include the Northern Expansion Project. This is a 700 acre development consisting of 600-ft wide slips and over 1 mi of waterfront. Phase I of the expansion is to be complete in 2001. While location on the Gulf of Mexico is an advantage to Port Fourchon, it has limited water access to major metropolitan centers. In addition, the two-lane LA Highway 1, the ports only access, and the lack of rail access are major impediments for the port. Chapter 3.3.3.2 also discussed the port and its conditions.

Port of Mobile, Alabama

With its deepwater seaport facilities at the Port of Mobile, the Alabama State Docks is conveniently located on the Central Gulf of Mexico. It is closer to open water than any other major port on the Gulf. There has been commerce in and out of the Port of Mobile since the early part of the 17th century. It was not until 1826 that the U.S. Congress authorized money for the development of a navigable channel in Mobile Bay. The current navigation channel, maintained by the U.S. Army Corps of Engineers, provides a navigational depth of 45 ft from the Gulf of Mexico to the mouth of the Mobile River. Four trunkline railroads (Burlington Northern/Santa Fe, CSX, Illinois Central, and Norfolk Southern) serve the port, which is situated at the intersection of two major interstate highways. The State offers 1,500 mi of navigable inland barge routes and is served by the Tennessee-Tombigbee Waterway, which connects 16,000 mi of interstate barge lanes with the Port of Mobile.

For the first 200 years of its existence, the Port of Mobile did not have a central organization to guide the development and operation of the port. In 1922 the State Docks Commission was established with the power to build, operate, and maintain wharves, piers, docks, quays, grain elevators, cotton compresses, warehouses, and other water and rail terminals, structures, and facilities. Since that time, the Alabama State Docks have been a part of Alabama State government and functions as an independent department with a board of directors. Today, the Department operates as a self-supporting enterprise agency of the Executive branch of State government.

About 375 employees operate, maintain, and market the facilities at the port. In 1999, the Port of Mobile was the 14th largest port in the nation in total tonnage. The economic impact to the State of Alabama was over $3 billion statewide. Tax payments of $467 million were made from activities in the international trade sector. And most importantly, the Alabama State Docks supports the jobs of more than 118,000 Alabamians.

The port offers 29 general cargo and 6 bulk berths with about 4 million ft^2 of covered storage space and an additional 4 million ft^2 of open storage area adjacent to piers and tracks. The general cargo capabilities have been enhanced in recent years, with about $80 million invested in capital improvement projects. New state-of-the-art wharves and warehouses include the 360,000-ft^2 Forest Products Terminal at Pier C, the 152,000-ft^2 Blakeley Terminal on the east bank of the Mobile River, the Steel & Heavy Lift Operations Berth at Pier North C, two warehouses with a combined space of 253,000 ft^2, a new pier for Roll On-Roll Off operations, and a concreted marshaling area. The port also provides a container port operation and other Roll O/Roll Off berths, accommodating some of the largest ocean-going vessels afloat. At present, the port is awaiting legislative approval for a $100 million appropriation that would fund a container intermodal facility.

As the industry continues to evolve so do the requirements of the onshore support network. With advancements in technology, the shore-side supply network continues to be challenged to meet the needs and requirements of the industry and will be challenged in the future. All supplies must be transported from land-based facilities to marine vessels or helicopters to reach offshore destinations. This uses both water and air transportation modes. The intermodal nature of the entire operation gives ports (who traditionally have water, rail, and highway access) a natural advantage as an ideal location for onshore activities and intermodal transfer points. Therefore, ports will continue to be a vital factor in the total process and must incorporate the needs of the offshore oil and gas industry into their planning and development efforts, particularly with regard to determining their future investment needs. In this manner both technical and economic determinants influence the dynamics of port development.

3.3.3.8.2. Navigation Channels

The analysis performed to identify current OCS service bases (Chapter 3.3.3.8.1) was also used to identify relevant navigation waterways that support OCS activities. Table 3-30 identifies the waterways and their project depth, while Figure 3-12 shows their locations throughout the analysis area. In addition to OCS activities, navigation waterways also attract recreational and commercial developments along their banks. These developments are generally dependent upon the water resources or transportation that those waterways make accessible.

3.3.3.8.3. Helicopter Hubs

Helicopter hubs or "heliports" are facilities where helicopters can land, load and offload passengers and supplies, refuel, and be serviced. These hubs are used primarily as flight support bases to service the offshore oil and gas industry. Most of the OCS-related helicopter trips originate at helicopter hubs in coastal Texas and Louisiana. There are 128 heliports in the analysis area that support OCS activities. Of the 128, most are in Louisiana: 7 are in TX-1, 32 in TX-2, 29 in LA-1, 28 in LA-2, 27 in LA-3, and 5 in MA-1. Three helicopter companies dominate the Gulf of Mexico offshore helicopter industry: Air Logistics, Era Aviation (Era), and Petroleum Helicopters, Inc. (PHI). A few major oil companies operate and maintain their own fleets, although this is a decreasing trend.

Offshore helicopter business volume is linked to drilling activity, which is in turn tied to the price of oil. When there is more cash flowing in the oil and gas industry, there is more drilling and therefore more helicopter trips (Craig, personal communication, 2001). As discussed in Chapter 3.3.3.2, due to the low price of oil ($10) during 1998-1999, the offshore oil and gas industry experienced a slowdown that resulted in a slowdown for the helicopter industry. During this time the oil and gas industry merged, consolidated, and formed alliances. Also, instead of running their own fleets, oil and gas companies are increasingly subcontracting all helicopter support to independent contractors. This trend is occurring largely because of oil-industry consolidation (Persinos, 1999). Also during this downturn, PHI's core business changed profoundly. In 1990, about 84 percent of PHI's core business came from the Gulf of Mexico oil and gas industry; now it is 76 percent. The company has increased its aeromedical market services.

The offshore helicopter business improved during 2000; this increase is attributed to increasing deepwater activity. Deepwater drilling, which is farther offshore, is the growth area for helicopters. At present, about 35 percent of PHI's business is in support of deepwater oil and gas activities. Era, the first of the three major helicopter companies to provide helicopter support of deepwater operations, has 50-60 percent of the deepwater market. Most of Era's work is in support of deepwater activities; they only have twin-engine helicopters rather than the single-engine helicopters that generally operate in shallower waters. To meet the demands of deepwater (travel further and faster, carry more personnel, all-weather capabilities, and the need for lower operating costs), the offshore helicopter industry is purchasing new helicopters. For example, Air Logistics recently purchased 38 helicopters: 10 new ones, 16 from Horizon, and Mobil's 12 helicopters. In the last few months, Air Logistics enlarged their fleets at Venice, Louisiana, and Harbor Island, near Corpus Christi, Texas. The helicopters operating in the Gulf of Mexico have travel ranges up to 450 nmi, can attain speeds over 200 mph, carry up to 20 passengers, and may cost $10 million or more.

While some heliports located farther inland have closed or consolidated, some heliports are expanding or opening due to more of the industry's work being farther offshore. Air Logistics has leased 90 additional acres at their heliport in Fourchon, Louisiana. Further, Air Logistics just completed a new heliport in Cameron (Creole), Louisiana, because of offshore activity. This is Air Logistics first new heliport in the last 20 years. Era Aviation is also expanding their facilities at Fourchon and Venice. The heliport in Fourchon will hold 1,500 cars and 15 helicopters, while the facility in Venice will increase three-fold.

Transportation is one of the offshore oil and gas industry's top three costs. Adding to this cost is the 30 percent rate increases levied by the three majors in the past year. While exploration and production companies like helicopters, the industry is outsourcing more and more operations to oilfield support companies, such as Baker Hughes, who are much more cost conscious and skeptical about the high cost of helicopters. Surface transportation, though, is not as feasible in deepwater. Another consideration for the helicopter industry is new technology such as subsea systems. As discussed in Chapter 4.1.1.3, a subsea system consists of a single subsea well or several wells producing either to a nearby platform or to a distant production facility through a pipeline and manifold system. These systems decrease the number of platforms and personnel needed offshore, therefore reducing the amount of transportation needed.

Seventy-five percent of the helicopter pilots in the Gulf of Mexico are members of the Office Professional Employees International Union (OPEIU). While pilots at PHI and Air Logistics have voted for the union, Era's pilots have not. Since unionization, pilots' salaries have increased. At the same time, however, the industry has experienced a pilot shortage that has also contributed to the larger salaries. Most helicopters need at least two pilots per helicopter. A majority of the pilots in the 50-60 age group, mostly Vietnam War pilots, are retiring. In addition, because of the decreasing size of the military, fewer pilots are available from the military pool. Furthermore, the offshore helicopter industry has trouble getting pilots and keeping them because of the shadow effect. People are leery of the oil and gas industry because of past layoffs. In response to this last problem, Air Logistics started a 'grow your own program' in which they are training pilots themselves.

3.3.3.8.4. Construction Facilities

Unless otherwise indicated, the following information is from the 2001 MMS study, "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book"(Louis Berger Group, Inc., in preparation).

Platform Fabrication Yards

Platforms are fabricated onshore then towed to an offshore location for installation. Facilities where platforms are fabricated are called platform-fabrication yards. Production operations at fabrication yards include cutting and welding of steel components, construction of living quarters and other structures, as well as assembling platform components. There are 43 platform fabrication yards located in the analysis area. Table 4-11 shows the distribution of platform fabrication yards by coastal subarea. Most of the yards are located in Louisiana (31). Major fabrication yards in the analysis area include Atlantic Marine, Friede Goldman, Gulf Island Fabricators, J. Ray McDermott, and Unifab International. The structure of the platform fabrication industry is currently undergoing a period of restructuring characterized by the transformation from privately to publicly held companies on the one hand to the consolidation of the industry through mergers and acquisitions.

The location of platform fabrication yards is tied to the availability of a navigable channel sufficiently large to allow for towing of bulky and long structures such as offshore drilling and production platforms. Thus, platform fabrication yards are located either directly on the coast of the Gulf of Mexico or inland, along large navigable channels, such as the Intracoastal Waterway. Average bulkhead depth for water access for fabrication yards in the Gulf is 15-20 ft. Most fabrication yards in the analysis area are located along the Intracoastal Waterway and within easy access to the Gulf of Mexico. At least 12 of these plants have deep channel access to their facilities, which allows them to easily handle deeper draft vessels required in deepwater. Several fabricators in the analysis area, though, have lost contracts to foreign competition for large, deepwater platforms due to lack of water depth.

For the most part, each yard has a specialty, whether it is the fabrication of separator or heater/treater skids, the construction of living quarters, the provision for hookup services, or the fabrication of jackets, decks and topside modules. Few facilities have complete capabilities for all facets of offshore projects. Despite the longer-term outlook most producers take toward offshore exploration and production, activity is still closely tied to the price of oil and gas. As prices drop, supporting industries such as fabrication become less busy, often resulting in layoffs that tend to drive experienced workers to other industries.

Due to the size of the fabricated product and the need to store a large quantity of materials such as metal pipes and beams, fabrication yards typically occupy large areas, ranging from a just few acres to several hundred acres. Typical fabrication yard equipment includes lifts and cranes, various types of welding equipment, rolling mills, and sandblasting machinery. Besides large open spaces required for jacket assembly, fabrication yards also have covered warehouses and shops. Because the construction of platforms is not likely to be standardized, an assembly-line approach is unlikely and most fabrication yards work on projects one at a time. Once a platform is completed, it is towed to its offshore location; work then begins on a new platform. The number of employees between fabrication yards varies from less than a hundred to several thousands, and due to the project-oriented type of work, temporary workers account for a significant portion of the workforce.

As mentioned, platform fabrication is not a mass production industry; every platform is custom built to meet the requirements of a specific project. This feature has given rise to a great degree of specialization in platform fabrication. No two fabrication yards are identical; most yards specialize in the fabrication of a particular type of platform or platform component. Examples of specialization include construction of living quarters, provision of hook-up services, and fabrication of jackets and decks. According to a published survey of fabrication yards in the Gulf of Mexico, 23 yards fabricate jackets, 15 fabricate decks, 29 fabricate modules, 22 fabricate living quarters, and 20 fabricate control buildings. Despite the specialization of these yards, most facilities do include

- steel stockyards and cutting shops that supply and shape steel;
- assembly shops that put together a variety of components such as deck sections, modules, and tanks;
- paint and sandblasting shops;
- drydocks that work on small vessels;
- piers that work on transportation equipment and the platform components that are mobile and can be transported onto barges; and
- pipe and welding shops.

Despite the large number of platform fabrication facilities in the analysis area, only a few facilities can handle large-scale fabrication. Nine yards have single-piece fabrication capacity over 100,000 tons and 12 have capacity to fabricate structures for water depths over 1,000 ft. Only a few yards fabricate structures other than fixed platforms: one fabricates compliant towers (J. Ray McDermott, Inc. in Amelia, Louisiana) and two fabricate tension-leg platforms (Gulf Island Fabrication Inc. in Houma, Louisiana, and Friede Goldman Offshore in Pascagoula, Mississippi). Another important characteristic of the industry is the high degree of interdependency and cooperation among the fabrication yards; offshore platforms, particularly the ones destined for deepwater, are such complex engineering projects, most facilities do not have the technical capabilities to complete the entire projects "in-house."

Over the history of its existence, the platform fabrication industry has been closely tied to the fortunes of the oil and gas industry. Drilling and production activities are sensitive to the changing prices for oil and gas. This sensitivity, in turn, is translated into "boom and bust" cycles for the fabrication industry, where a period of no work follows a period of more fabrication orders than a yard can complete. In order to shield themselves from the volatility inherent in the oil and gas industry, platform fabrication yards in the analysis area have started to implement various diversification strategies. These diversification strategies, coupled with the new challenges brought about by deepwater oil and gas exploration and development, are significantly changing the industry.

In order to use the existing equipment and to retain their highly-skilled workforce during periods of low or no fabrication orders, many fabrication yards are expanding their operations into areas such as maintenance and renovations of drilling rigs, fabrication of barges and other marine vessels, dry-docking, and surveying of equipment. These projects, although much smaller in scale and scope than platform fabrication, allow the yards to survive during low periods. Another avenue of diversification is pursuit of international platform fabrication. For example, McDermott does fabrication for offshore waters in the Far East and Middle East. Fabrication yards in the analysis area have the advantages of vast experience in fabrication work and good climatic conditions that allow for year-round operations. Fabrication companies have also developed new offshore management software and company specific systems for managing and monitoring offshore sites onshore. New and improved platforms or platform upgrades and revamps complement many of these systems and software.

The platform fabrication industry has experienced a lack of skilled workers at the beginning of an upswing in the business cycle; during the downswing the skilled labor migrates to other jobs. Having learned from past mistakes, some fabrication companies have organized technical training programs in the local communities. A locally trained workforce provides a readily available pool of skilled labor for the fabrication yards. Other companies have found a solution to the workforce problem through the acquisition of several individual fabrication yards located within the commuting area. This allows companies to dispatch their personnel to several yards to accommodate the existing need at any given time.

Pipecoating Plants and Yards

Pipecoating plants generally do not manufacture or supply pipe. They receive the manufactured pipe by rail or water at either their plant or pipe yard depending on their inventory capabilities. At the plant, pipe surfaces are coated with metallic, inorganic, and organic materials to protect from corrosion and abrasion. This process also adds weight to counteract buoyancy. Sometimes the inside of the pipe is also coated for corrosion control. Two to four sections of pipe are then welded at the plant into 40-ft segments. The coated pipe is stored (stacked) at the pipe yard until it is needed offshore. It is then placed on barges or layships where the pipeline contractor welds the 40-ft sections together, and cleans and coats the newly welded joints. Finally, the pipe is laid.

There are currently 19 pipecoating plants in the analysis area (Table 4-11). Twelve of the 19 plants are located in coastal Subareas TX-2 and LA-2. There are two pipecoating plants in the Mississippi-Alabama area, two in the Florida Panhandle area, and one near Tampa, Florida. To meet deepwater demand, pipecoating companies have been expanding capacity or building new plants. Major pipecoating companies in the analysis area are Bayou, Bredaro Price, eb, and Womble. Many pipecoating plants also handle pipe for non-OCS companies, other countries, and non-petroleum-related industries.

The pipecoating industry is labor intensive. The coatings are mostly applied by hand. The companies try to maintain a core base of laborers, then either scale up or down with temporary labor according to workload. Due to the cyclical nature of the business, maintaining labor is a problem for the industry. In addition, pipecoating companies compete with other infrastructure industries for welders. In order to reduce this problem, several companies have started welding training programs. Bredaro Price has brought international labor to their Mobile plant in an effort to bring in experience and knowledge. They were also able to hire labor from a local paper mill that closed. Safety is a big part of the pipecoating business. Bredaro Price recently added money to their Mobile plant to automate rolling pipe. This has decreased the amount of labor needed, increased the amount of skilled labor needed, and decreased the number of accidents at the plant.

Some pipecoating plants are affiliated with a mill. These are American mills that manufacture high-grade pipe with light walls that can be used in shallow water. Foreign mills, mostly in Europe and Japan, manufacture heavy-walled pipe needed for deepwater pressure. U.S. Steel in Youngstown, Ohio, currently has the capability to manufacture the thick pipe necessary for deepwater, but it lacks the processing needed to heat-treat the pipe. Pipecoating customers are both exploration and production operators (direct) and pipelaying contractors (subcontracting). A new trend in the industry is single-source contracts where the pipe manufacturing, coating, welding, and laying are all under one contract. This results in a more efficient, less costly operation. At present, only foreign companies have this capability.

Shipyards

The 1980's were dismal times for the shipbuilding industry. This was brought about by a combination of factors that included lack of a comprehensive and enforced U.S. maritime policy, failure to continue funding subsidies established by the Merchant Marine Act of 1936, and the collapse of the U.S. offshore oil industry, which not only hurt the shipbuilding industry but all support industries such as small shipyards and repair yards. Approximately 120,000 jobs for shipyard workers and shipyard suppliers were lost.

At present, there are about 106 shipyards in the United States with the capability of repairing oceangoing ships greater that 400 ft in length. Only 19 are capable of building large oceangoing vessels, while the rest deal mainly in repairs. This is a decrease of approximately 40 percent from what was available at the start of the 1980’s. Several mergers, acquisitions, and closings occurred during the downturn. In addition to the major shipyards, there are about 2,600 other companies that build or repair other craft such as tugboats, supply boats, ferries, fishing vessels, barges, and pleasure boats. Within the analysis area, there are 94 shipyards (Table 4-11). Major shipyards in the analysis area include Bollinger Shipyards; Harrison Brothers Dry Dock & Repair Yard, Inc.; First Wave/Newpark Shipyards; Edison Chouest Offshore: North American Shipbuilding in Larose, Louisiana (an ECO affiliate); North American Fabricators in Houma, Louisiana (an ECO affiliate); and Litton Ship Systems: Avondale\The Shipyards Division and Ingalls Shipyard.

The American Shipbuilding Association is the professional organization for those in the industry who are capable of constructing mega vessels that are in excess of 400 ft in length and weigh in excess of 20,000 dead weight tonnage (DWT). For this reason, their membership consists of only six companies. Of those six, two have a presence in the Gulf of Mexico. Both Avondale Shipyard of New Orleans, Louisiana, and Ingalls Shipyard of Pascagoula, Mississippi, have enormous capabilities and expertise in the design, construction, and repair of vessels. This highly developed level of specialized knowledge has made these two companies ideal contractors for the nation’s defense efforts. Therefore, most of the work that has been accomplished in these two yards has been for the U.S. military.

The existence of enormous commercial needs has led to the development of a very large number of boat and barge builders. These companies have directed their efforts toward the requirements of specific industries such as the offshore oil and gas industry, which is undergoing a recovery from the marked decline of the 1980’s. The vessels they produce are not as large as those being built by Avondale and Ingalls. However, as the oil and gas industry has evolved and become more sophisticated, particularly with deepwater drilling, so too has the capability of this segment of the boat-building industry. The need for supply and other types of industry support vessels has increased. With changing technology has come the need for more sophisticated and higher capacity vessels. Many of these companies are now producing ships in the 300-ft range. As discussed in Chapter 3.3.3.8.2, service-vessel operators ordered over 100 vessels during the last newbuild cycle. Over a dozen shipyards participated, with Halter Marine (now part of Friede Glodman) being the most active. Other shipyards participating included (in decreasing order): Ingalls, North American, Leevac, Bender, Atlantic Marine, Service Marine, Eastern, Conrad, Houma Fabrication, Bollinger, Seafab, Steiner, and McDermott. Five of the six most active shipyards are still in the commercial business and all are actively pursuing further supply-vessel opportunities. Ingalls has narrowed its focus to government work and is no longer building commercial vessels.

Several pertinent issues have affected and will continue to affect shipbuilding in the U.S. and particularly in the analysis area—maritime policy, declining military budget, foreign subsidies, USCG regulations, OPA 90, financing, and an aging fleet. These issues are discussed below.

Since the 1980’s, military spending for new ship construction has declined. During that administration a 600-vessel fleet was envisioned. During the Bush tenure that figure dropped to 420 vessels. The current vessel fleet is less than 350 ships. Despite the downsizing, there will continue to be military associated work. Downsizing itself will provide deactivation work for many shipyards. There should be an increase in overhauls, repairs, and service life extensions. In addition, the Navy has affirmed a need for Sealift capabilities. Some vessels will be converted for this usage.

Most foreign nations subsidize their shipbuilding industries. Methods to accomplish this include construction subsidies, investment subsidies, research and development subsidies, preferential tax policies, officially financed export credits, reduced financing rates, loans, and loan guarantees. The type and amount of government support varies from country to country. At present, the U.S. does not have a subsidy or incentive program available for a foreign or domestic owner to build a large vessel in this country.

All U.S.-built vessels must comply with USCG rules and regulations. This automatically increases the cost of the vessel by 10-12 percent over the cost of a vessel built outside of the U.S. for international trade. In addition, OPA 90 requires that all new tank vessels trading in U.S. waters be equipped with double hulls and that existing tankers without double hulls be retrofitted or removed from oil production transportation. A phase-out schedule was established to implement the requirements of this legislation.

Passage of OPA 90 resulted in some new construction of double-hulled tank vessels. This helped to bring about a slight upturn in the industry.

Lastly, it is difficult to obtain financing to build large ships in the U.S. Rules and regulations of the Export-Import Bank are complex and difficult to interpret. The aging fleet, together with increasing environmental concerns, will provide an opportunity for additional construction and repair activities. The Jones Act requires that vessels that transport cargo between ports or points in the U.S. be constructed in the United States.

3.3.3.8.5. Processing Facilities

Unless otherwise indicated, the following information is from the 2001 MMS study, "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

Refineries

Petroleum is a mixture of liquid hydrocarbons formed beneath the earth's surface. Found in both gaseous and liquid form, the exact composition of these hydrocarbons varies according to locality. Crude oil is a mixture of hydrocarbon compounds and relatively small quantities of other materials such as oxygen, nitrogen, sulfur, salt, and water. Crude oil varies in color and composition from a pale yellow, low-viscosity liquid to a heavy black tar consistency. Because it is of little use in its raw state, further processing of crude oil is necessary to unlock the full potential of this resource.

A refinery is an organized arrangement of manufacturing units designed to produce physical and chemical changes to turn crude oil into petroleum products. Refineries vary in size, sophistication, and cost depending on their location, the types of crude they refine, and the products they manufacture. Because crude oil is not homogeneous (varying in color, viscosity, sulfur content, and mineral content), oil produced from different fields or geographic areas have different quality characteristics that give rise to different economic values.

In the refinery, most of the nonhydrocarbon substances are removed from crude oil, and the oil is broken down into its various components and blended into useful products. Every refinery begins with the separation of crude oil into different fractions by distillation. The fractions are further treated to convert them into mixtures of more useful saleable products by various methods such as cracking, reforming, alkylation, polymerisation, and isomerisation. These mixtures of new compounds are then separated using methods such as fractionation and solvent extraction.

Because there are various blends of different crude oils available, different configurations of refining units are used to produce a given set of products. A change in the availability of a certain type of crude oil can affect a refinery's ability to produce a particular product. For example, one important crude quality is gravity. Stated in API degrees (API^{o}), gravity is a measure of the density of the crude oil and can affect the complexity of a refinery. The higher the gravity, the lighter the crude and, conversely, the lower the gravity, the heavier the crude. A second quality measure is sulfur content. Sulfur content is usually measured in terms of the percentage of the crude's weight that is comprised by sulfur. Low-sulfur or "sweet" crudes typically have less than 0.5 percent sulfur content. Crude oil considered high sulfur or "sour" typically has over 0.5 percent sulfur content.

These two qualities are important in refining. Heavy crudes require more sophisticated processes to produce lighter, more valuable products; therefore, they are expensive to manufacture. Because of its corrosive qualities, higher sulfur content makes a crude more expensive to handle and process. In general, light crudes are more valuable, i.e., they yield more of the lighter, higher-priced products than heavy crudes. The product slate at a given refinery is determined by a combination of demand, inputs and process units available, and the fact that some products are the result (co-products) of producing other products.

In the early 1970's, the Federal Government set price controls that gave an economic advantage to refineries that had access to low-cost domestic oil. In 1975, the "Crude Oil Entitlements Program" was implemented to distribute oil supplies among refiners. This program basically provided a subsidy to small refining companies, many of which had simple "topping" facilities and little or no downstream processing capability. (A simple "topping" refinery will have a distillation tower and possibly a reformer and some sulfur treating capability, while complex refineries will have more extensive downstream facilities.) A refiner who had access to light crude oils needed only a distillation tower to produce motor gasoline. Therefore, many simple refineries sprang up across the country, most notably in the analysis area.

In the early 1980's, the Crude Oil Entitlements Program ended and crude oil prices were no longer controlled. This caused the number of petroleum refineries to drop sharply, leading to 13 years of decline in U.S. refining capacity. Between 1981 and 1989, the reduction in the number of refineries from 324 to 204 represented a loss of 3 million barrels per day (Mbbl/day) in operable capacity. Another 41 refineries (mainly small) shut down between 1990 and 1997. Since the 1980's, the refining industry's focus has turned from increasing crude oil distillation capacity to investment in downstream charge capacity, thereby increasing overall refinery complexity. This transition began several years before the passage of the Clean Air Act Amendments in 1990 as a result of increased demand for lighter, cleaner products that have to be produced from increasingly heavier and more-sour crude oils.

The decade of the 1990's was characterized by low product margins and low profitability. Stiff environmental mandates stemming from 1990 amendments to the Clean Air Act heaped capital costs on the industry at a time of relatively flat product demand. By implementing massive capital spending programs, refiners met and surpassed plant emission goals while retooling to produce a new generation of cleaner burning fuels. Low profitability was also partially due to the narrowing of the spread between petroleum product prices and raw material input costs. Additionally, persistently low profits prompted domestic refiners and marketers to make concerted efforts to realize greater value from their fixed assets and to reduce their operating costs. Refining operations were consolidated, the capacity of existing facilities was expanded, and several refineries were closed.

The analysis area hosts over one-third of the petroleum refineries in the U.S. Most of the region's refineries are located in Texas and Louisiana (Table 4-11). Texas has 19 refineries, with a combined crude oil operating capacity of 3.9 Mbbl/day, while Louisiana has 14 refineries with 2.7 Mbbl/day of operating capacity, representing 55.04 and 38.49 percent, respectively, of total U.S. refining capacity. Most refineries are part of major, vertically integrated oil companies that are engaged in both upstream and downstream aspects of the petroleum industry. These companies dominated the refining industry, although most majors are spinning off their refinery facilities to independents or entering joint ventures to decrease the risk associated with low refining returns. The top 10 U.S. refiners, all of them major, integrated oil companies, account for about 60 percent of the total domestic refinery operating capacity.

By consolidating operations and sharing assets and operations, downstream petroleum companies hope to be able to increase the value of their fixed assets and reduce their costs. The largest of the recent joint ventures affecting U.S. refining and marketing was announced in late 1996 but was not completed until early 1998. That venture merged Texaco, Star Enterprise (a joint venture between Texaco and Aramco, the Saudi Arabian state oil company), and Shell Oil (the U.S. subsidiary of Royal Dutch/Shell). The joint venture resulted in the creation of two companies, Equilon Enterprises L.L.C. and Motiva Enterprises L.L.C (in January and May, 1998, respectively). Equilon consisted of the companies' western and midwestern U.S. operations as well as their nationwide trading, transportation, and lubricants businesses. Motiva consisted of the companies' eastern and U.S. Gulf Coast operations (with the exception of Shell's Deer Park, Texas, refinery, which is operated as a joint venture between Shell Oil and the state oil company of Mexico, Petroleos Mexicanos (PEMEX)).

Significant mergers have also occurred between independent refiners and marketers. However, unlike the major U.S. petroleum companies, which are consolidating their refining and marketing operations through joint ventures, the independent refiners and marketers are expanding their operations through mergers and, at least in one case, joint ventures. For example, in 1997 Ultramar Diamond Shamrock (itself created by a late 1996 merger) acquired Total Petroleum North America, gaining three refineries, more than 2,100 marketing outlets, and hundreds of miles of pipelines, in addition to other associated assets.

Petrochemical Plants

The chemical industry converts raw materials such as oil, natural gas, air, water, metals, and minerals into more than 70,000 different products. The non-fuel components derived from crude oil and natural gas are known as petrochemicals. Petroleum is composed mostly of hydrogen and carbon compounds (called hydrocarbons). It also contains nitrogen and sulfur, and all four of these components are valuable in the manufacture of chemicals.

The industrial organic chemical sector includes thousands of chemicals and hundreds of processes. In general, a set of building blocks (feedstocks) is combined in a series of reaction steps to produce both intermediate and end products. The processes of importance in petrochemical manufacturing are distillation, solvent extraction, crystallization, absorption, adsorption, cracking, reforming, alkylation, isomerization, and polymerization.

The boundaries of the petrochemical industry are rather unclear. On the upstream end, they blend into the petroleum refining sector, which furnishes a major share of petrochemical feedstocks; downstream it is often impossible to draw a clear line between petrochemical manufacturing and other organic chemistry-based industries such as plastics, synthetic fibers, agricultural chemicals, paints and resins, and pharmaceuticals. Operating in this field are petroleum companies who have broadened their interests into chemicals, chemical companies who buy raw petroleum materials, and joint ventures between chemical and petroleum companies.

Texas, New Jersey, Louisiana, North Carolina, and Illinois are the top U.S. chemical producers. However, most of the basic chemical production is concentrated in the analysis area, where petroleum and natural gas feedstocks are available from refineries. About 70 percent of all primary petrochemicals are produced in Texas and Louisiana. At present, there are 29 petrochemical plants in the analysis area, all of which are in Texas or Louisiana. The distribution of these plants by subarea is shown in Table 4-11.

Chemical manufacturing facility sites are typically chosen for their access to raw materials and to transportation routes. And, because the chemical industry is its own best customer, facilities tend to cluster near such end-users. A small number of very large facilities account for the majority of the industry's value of shipments. The 16 largest plants (greater than 1,000 employees) manufacture about 25 percent of the total value of shipments.

Laid out like industrial parks, most petrochemical complexes include plants that manufacture any combination of primary, intermediate, and end-use products. Changes in market conditions and technologies are reflected over time in the changing product slates of petrochemical complexes. In general, petrochemical plants are designed to attain the cheapest manufacturing costs and thus are highly synergistic. Product slates and system designs are carefully coordinated to optimize the use of chemical by-products and to use heat and power efficiently.

The transformation of raw materials into chemical products requires chemical, physical, and biological separation and synthesis processes. These processes use large amounts of energy for heating, cooling, or electrical power. The industry is the single largest consumer of natural gas (over 10% of the domestic total) and uses virtually all the liquefied petroleum gas (LPG) consumed in U.S. manufacturing. Other energy sources include by-products produced onsite, hot water, and purchased steam. Physical and biological separation plays a critical role in processing and accounts for 40-70 percent of both capital and operating costs. The most widely used separation process is distillation, which accounts for as much as 40 percent of the industry's energy use. Chemical synthesis is the backbone of the industry; process heat is integral and supports nearly all chemical operations.

Gas Processing Plants

After raw gas is brought to the earth's surface, it is processed at a gas processing plant to remove impurities such as water, carbon dioxide, sulfur, and inert gases, and it is transformed into a sellable, useful energy source. It is then moved into a pipeline system for transportation to an area where it is sold. Because natural gas reserves are not evenly spaced across the continent, an efficient, reliable gas transportation system is essential. At present, there are 35 gas processing plants in the analysis area that process OCS-produced gas; 28 of these are in Louisiana. The distribution of these plants by coastal subarea is shown in Table 4-11. Major operators include BP, Exxon, Dynergy, Duke Energy, and El Paso.

Natural gas is found below the earth's surface in three principal forms. Associated gas is found in crude oil reservoirs, either dissolved in the crude oil, or combined with crude oil deposits. This gas is produced from oil wells along with the crude and is separated from the oil at the head of the well. Non-associated gas is found in reservoirs separate from crude oil; its production is not a result of the production of crude oil. It is commonly called "gas-well gas" or "dry gas." Today about 75 percent of all U.S. natural gas produced is nonassociated gas. Gas condensate is a hydrocarbon that is neither true gas nor true liquid. It is not a gas because of its high density, and it is not a liquid because no surface boundary exists between gas and liquid. Gas condensate reservoirs are usually deeper and have higher pressures, which pose special problems in the production, processing, and recycling of the gas for maintenance of reservoir pressure.

The quality and quantity of components in natural gas vary widely by the field, reservoir or location from which the natural gas is produced. Although there is not a "typical" makeup of natural gas, it is primarily composed of methane (the lightest hydrocarbon component) and ethane. In general, there are four types of natural gas: wet, dry, sweet, and sour. Wet gas contains some of the heavier hydrocarbon molecules and water vapor. When the gas reaches the earth's surface, a certain amount of liquid is formed. A wet gas may contain five or more gallons of recoverable hydrocarbons per thousand cubic feet; the water has no value. If the gas does not contain enough of the heavier hydrocarbon molecules to form a liquid at the surface, it is a dry gas. Sweet gas has very low concentrations of sulfur compounds, while sour gas contains excessive amounts of sulfur and an offensive odor. Sour gas can be harmful to breathe or even fatal.

Centrally located to serve different fields, natural-gas processing plants have two main purposes: (1) remove essentially all impurities from the gas; and (2) separate the gas into its useful components for eventual distribution to consumers. The modern gas-processing industry uses a variety of sophisticated processes to treat natural gas and extract natural-gas liquids from the gas stream. The two most important extraction processes are the absorption and cryogenic expander process. Together, these processes account for an estimated 90 percent of total natural-gas liquids (NGL) production.

The total number of natural-gas processing plants operating throughout the U.S. has been declining over the past several years as companies have merged, exchanged assets, and closed older, less efficient plants. This trend was reversed in 1999; Louisiana's capacity is undergoing significant increases as a wave of new plants and expansions try to anticipate the increased volumes of natural gas coming ashore from new gas developments in the Gulf of Mexico. New plants were also built in Mobile, Alabama, and Pascagoula, Mississippi. There are approximately 581 operating gas-processing plants in the U.S., most of which are located in eight states: California, Colorado, Louisiana, Michigan, New Mexico, Oklahoma, Texas, and Wyoming. Louisiana continues to lead other U.S. states in the number of gas-processing plants, followed closely by Texas. Between them, the two states hold more than 52 percent of the nation's gas-processing capacity. In 1999, the two states produced more than half of the NGL produced in the U.S. Texas produced nearly 43.5 percent (up from 41% in 1998) while Louisiana produced over 17.8 percent (up from 15% in 1998).

3.3.3.8.6. Terminals

Pipeline Shore Facilities

The term "pipeline shore facility" is a broad term describing the onshore location where the first stage of processing occurs for OCS pipelines carrying different combinations of oil, condensate, gas, and produced water. These facilities may also be referred to as a separation or field facilities. Pipelines carrying only dry gas do not require pipeline shore facilities; the dry gas is piped directly to a gas processing plant (Chapter 3.3.3.8.5). Although in some cases some processing occurs offshore at the platform, only onshore facilities are addressed in this section.

Pipeline shore facilities may separate, process, pump, meter, and store oil, water, and gas depending on the quality of the resource carried by the pipeline. After processing and metering, the liquids are either piped or barged to refineries or storage facilities. The gas is piped to a gas processing plant for further refinement, if necessary; otherwise it is transported via transmission lines for distribution to commercial consumers. Water that has been separated out is usually disposed into on-site injection wells.

A pipeline shore facility may support one or several pipelines. Typical facilities occupy 2-25 ha. The distribution of existing pipeline shore facilities associated with the OCS Program are given in the table below. These facilities are also shown on Figure 3-13.

Existing Pipeline Shore Facilities for the OCS Program (2003-2042) by Coastal Subarea

TX-1	TX-2	LA-1	LA-2	LA-3	MA-1	FL-1	Total
6	7	18	10	9	0	0	50

Barge Terminals

Barge terminals are the receiving stations where oil is first offloaded from barges transporting oil from OCS platforms. These facilities usually have some storage capabilities and processing facilities. Some barge terminals may also serve as pipeline shore facilities.

Most of the land required at a barge terminal is for storage tanks. Space requirements range from 6 to 25 ha (NERBC, 1976).

Eight barge terminals along the Gulf Coast are currently being used by the OCS oil industry (Table 3-3-34 and Figure 3-14). Of the four barge terminals in Louisiana, three receive oil from only CPA leases and one receives oil from both WPA and CPA leases. Of the four barge terminals in Texas, three receive oil from only WPA leases and one receives oil from only CPA leases. These barge terminals may also receive oil from State production or imports. Texas terminals receive approximately 30 percent of OCS barged oil and Louisiana terminals receive approximately 70 percent.

Chapter 3.3.3.8.9 discusses OCS barging operations in general.

Tanker Port Areas

The transport of OCS-produced oil from FPSO operations to shore facilities would be accomplished with shuttle tankers rather than oil pipelines. The FPSO's temporarily store produced oil on location within the hull of the FPSO; the oil is periodically transferred to shuttle tankers. Shuttle-tanker transport could also be used in support of extended well-test operations or for transporting produced oil from other OCS deepwater facilities. Shuttle-tanker destination ports are determined by channel depthproximity to refineries. Channel-depth requirements are based on tanker size and draft. In the Gulf of Mexico, the 34- to 47-ft water depths of refinery ports limit the maximum size of shuttle tankers to about 500,000 bbl of crude oil cargo. The following refinery ports are currently the likely destinations for shuttle tankers transporting crude oil from FPSO operations in the Gulf of Mexico: Corpus Christi, Freeport, Port Arthur/Beaumont, and Houston/Galveston, Texas; and Lake Charles, the lower Mississippi River ports (Baton Rouge, Port of South Louisiana, New Orleans, and Plaquemines), and the Louisiana Offshore Oil Port, Louisiana.

3.3.3.8.7. Disposal and Storage Facilities for Offshore Operations

Unless otherwise stated, the following information is from the 2001 MMS study "Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book" (Louis Berger Group, Inc., in preparation).

The infrastructure network needed to manage the spectrum of waste generated by OCS exploration and production activities and returned to land for management can be divided into three categories:

(1) transfer facilities at ports, where the waste is transferred from supply boats to another transportation mode, either barge or truck, toward a final point of disposition;

(2) special-purpose, oil-field waste management facilities, which are dedicated to handling particular types of oil-field waste; and

(3) generic waste management facilities, which receive waste from a broad spectrum of American industry, of which waste generated in the oil field is only a small part.

The first two categories lend themselves to a capacity analysis while the third does not. Table 4-11shows the waste disposal facilities in the analysis area by subarea.

The capacity of a waste facility has two dimensions. The first is the throughput capacity over a given period of time. In the short term, a waste facility can face limits to the volume of waste it accepts either from permit conditions or from physical limitations to the site, such as unloading bays, traffic conditions, or equipment capacity. Life-of-site capacity is also a limiting factor for disposal facilities. Limitations of storage space or, in the case of an injection well, service life of the well make it necessary to consider what must happen after existing facilities have exhausted their capacity.

A number of different types of waste are generated as a result of offshore exploration and production activity. The different physical and chemical character of these wastes make certain management methods preferable over others. The types of waste include

- solids, such as drill cuttings, pipe scale, produced sand, and other solid sediments encountered during drilling, completion, and production phases;
- aqueous fluids having relatively little solids content, such as produced waters, waters separated from a drilling mud system, clear brine completion fluids, acids used in stimulation activities, and wash waters from drilling and production operations. (Although most of these are potentially dischargeable under the NPDES general permit, the possibility always exists that some amount of material will become contaminated beyond the limits of treatment capabilities and will require disposal in a land-based facility. A minute percentage of the total volume consists of chemicals (such as zinc bromide), which do not meet discharge criteria.);
- drilling muds (oil-based, synthetic, or water-based);
- naturally occurring radioactive materials (NORM), such as tank bottoms, pipe scale, and other sediments that contain naturally high levels of radioactive materials. (NORM occurs in sludge and also as scale on used steel vessels and piping when equipment has been exposed to other NORM materials after very long periods of use.);
- industrial hazardous wastes, such as solvents and certain compounds, with chemical characteristics that render them hazardous under Subtitle C of the Resource Conservation and Recovery Act (RCRA) and thus not subject to the exemption applicable to wastes generated in the drilling, production, and exploration phases of oil and gas activities;
- nonhazardous industrial oily waste streams generated by machinery operations and maintenance, such as used compressor oils, diesel fuel, and lubricating oils, as well as pipeline testing and pigging fluids. (Wastes from marine transportation as well as pipeline construction and operations are always classified as industrial wastes, while some operators and State regulators may choose to handle or classify waste from drilling and production machinery this way. Used oil generated by exploration and production operations may legally be mixed with produced oil, but refineries discourage the practice. These streams often become commingled with wash water. They may be handled in drums or in bulk as part of a larger waste stream.); and
- municipal solid waste generated by the industry's personnel on offshore rigs, platforms, tankers, and workboats.

Federal regulations govern what may be discharged in Gulf of Mexico waters and set different standards in different parts of the Gulf Coast. Table 3-35 summarizes current Federal rules. Wastes that cannot be discharged or injected offshore must be brought to shore. Transportation, packaging, and unloading of the waste at ports are governed by U.S. Department of Transportation (DOT) regulations while the USCG regulates vessel fitness. Once on the dock, transportation and packaging is subject to an overlay of DOT and State laws. State regulations governing reporting and manifesting requirements may vary somewhat, but Federal law has, for the most part, preempted the field of transportation waste regulation. Dockside facilities that serve as transfer points from water to land modes of transportation are regulated by both USCG and State regulations covering the management of oil-field wastes.

Once at a waste management facility, regulations regarding storage, processing, and disposal vary depending on the type of waste. Most would fall under the oil and gas waste exemption of RCRA Subtitle C and would be subject only to State regulations regarding the disposal of oil-field wastes. A minute volume of the waste would be subject to Federal regulation as hazardous waste under RCRA Subtitle C. State laws governing hazardous wastes are allowed to be more restrictive than Federal law, but no material differences exist between State and Federal law in Texas, Louisiana, Mississippi, or

Alabama. For the most part, the wastes generated by oil-field activities, called nonhazardous oilfield waste (NOW) are exempt from hazardous waste regulation by Federal law because they are produced from the exploration, development, or production of hydrocarbons and thus fall under what is generally referred to as the oil and gas waste exemption found in 40 CFR 261.

Waste fluids and solids containing NORM are subject to State regulations that require special handling and disposal techniques. There are currently no Federal regulations governing NORM. The special handling and disposal requirements for NORM generally result in the segregation of these materials from NOW and in substantially higher disposal costs when managed by commercial disposal firms.

Commercial disposal of NORM is available in Texas at two different sites. Alabama has not fully developed its NORM regulatory program, but waste within 5 piC/g of background is considered acceptable for on-site disposal. The NORM waste generated in Mississippi, Alabama, and Florida is typically shipped to Louisiana or Texas.

Differences in laws among the states lead to differences in waste management methods as well as industry preferences in the siting of waste facilities in certain states. The substantive differences that distinguish the states are comparatively few. Texas allows and regulates salt dome disposal of waste, while no other state does. Louisiana, Alabama, and Mississippi allow the landfilling of used oil filters and oil-based drilling muds, while Texas requires them to be recycled. Texas generally has stricter limits on the hydrocarbon content of waste going into municipal landfills. Texas also has regulations allowing oil-based drilling mud to be recycled through bioremediation into road-building material. None of the other Gulf States have enabled oil-field waste land application recycling operations in their regulatory framework.

The USEPA has established a hierarchy of waste management methods that it deems preferentially protective of the environment. For those technologies applicable to oil and gas production waste, the following general waste management techniques are described in order of USEPA's preference:

- Recycle/Reuse—When usable components such as oil or drilling mud can be recovered from a waste, these components are not discarded and do not burden the environment with impacts from either manufacturing or disposal.
- Treatment/Detoxification—When a waste cannot be recycled or reused, it can sometimes be treated to remove or detoxify a particular constituent prior to disposal. Neutralization of pH or removal of sulfides are examples of technologies that are used with oil and gas wastes.
- Thermal Treatment/Incineration—Wastes with organic content can be burned, resulting in a relatively small amount of residual ash that is incorporated into a product or sent to disposal. This technology results in air emissions, but the residuals are generally free of organic constituents.
- Subsurface Land Disposal—This technology places waste below usable drinking water resources and is viewed as superior to land filling because of the low potential for waste migration. Injection wells and salt cavern disposal are examples of this type of technology.
- Surface Land Disposal/Treatment—This type of technology involves the placement of wastes into a landfill or onto a land farm. Although well-designed and constructed landfills minimize the potential for waste migration, generators remain concerned about migration of contaminants into water resources and avoid it whenever practical. The USEPA classifies surface land disposal as the least desirable disposal method.

Several waste management methods are used to handle the spectrum of wastes generated by OCS activity, and most types of wastes lend themselves to more than one method of management. Each option has a different set of environmental impacts, regulatory constraints, costs, and capacity limitations.

Subsurface injection is the management method used for more than 90 percent of the 16 billion barrels of saltwater produced by onshore oil and gas production each year in the U.S.

Nonhazardous Oil-field Waste Sites

Most of the OCS solids-laden waste streams arepresently injected at one facility, Newpark Environmental Services near Fannett, Texas. It is the most important NOW facility for the offshore industry, having received some 5 million barrels of offshore waste in 1998, constituting about 75 percent of the total offshore NOW streams shipped ashore. This facility has a number of injection wells, not all of which are needed at any given time. Any number of other injection wells are available on the Gulf of Mexico coast, but few have Newpark's capability to handle solids-laden streams, and few have focused on the logistical requirements of the offshore market to the extent Newpark has. These factors account for the Newpark facility's very large share of the offshore market. Newpark appears to have some economies of scale that serve to offset the cost of a long barge trip back from transfer points such as Port Fourchon.

The Newpark facility near Winnie, Texas, has five wells completed into the caprock of a salt dome that is permitted to inject up to 17.5 million barrels per year of slurried solids. A separate Newpark facility near Big Hill, Texas, also in Jefferson County, has three injection wells dedicated to injecting NORM. It received 13,900 bbl of NORM solids in 1999 and 16,500 bbl in 1988. The NORM waste receipts are trending down because operators are careful to segregate NORM to minimize the volumes that must be disposed of at a comparatively high commercial price.

One commercial salt cavern, operated by Trinity Field Services, has recently opened near Hamshire, Texas, on the Trinity River. It presently receives waste only by truck, although management expects a barge mooring to be permitted within a year. If the company is successful in obtaining additional permits that would allow receipt by barge and securing dock space in ports to serve as transfer points, then the company may present a significant source of new capacity—perhaps on the scale of Newpark's. Four other commercial salt domes are operational in northeastern and western Texas. One commercial salt dome, Lotus, L.L.C. in Andrews County near the New Mexico border, accepts NORM, some of which comes from offshore operations. Due to their distance from the Gulf Coast, no others receive any OCS waste. With the addition of Trinity Field Services bringing 6.2 million barrels of available space to the market, enough to take 8-10 years' worth of OCS liquids and sludges at current rates, the OCS has its first salt dome disposal operation in a competitive location.

Landfills

Workers on a rig or production platform generate the same types of waste as any other consumer in industrial society and are therefore responsible for their fair share of municipal solid waste (MSW). Landfarm facilities are available to accept offshore waste but actually accept very little because offshore operators prefer other methods. The MSW disposal from OCS activities currently imposes only a small incremental load on landfills in the analysis area, probably no more than 5 percent of total receipts by all the landfills serving south Louisiana.

3.3.3.8.8. Coastal Pipelines

This section discusses OCS pipelines in coastal waters (State offshore and inland waters) and coastal onshore areas. The OCS pipelines near shore and onshore may join pipelines carrying production from State waters or territories for transport to processing facilities or to distribution pipelines located farther inland. See Chapter 3.3.3.9.2 for a discussion of pipelines supporting State oil and gas production.

Nearly 400 OCS pipelines cross the Federal/State boundary into State waters. There are nearly 1,700 km of OCS pipelines in State waters, with an average of 5 km per pipeline. Over half of the pipelines in State waters are directly the results of the OCS Program.

Where a pipeline crosses the shoreline is referred to as a pipeline landfall. Gulfwide, two-thirds of OCS pipelines entering State waters tie into existing pipeline systems and do not result in new pipeline landfalls. Because of the extensive trunklines that parallel the Texas coastline, this ratio is lower in Texas. About 85 percent of OCS pipeline landfalls are in Louisiana. The oldest pipeline systems are also in Louisiana; some datie back to the 1950's. The OCS pipelines making landfall have resulted in 700 km of pipelines onshore, with an average of 10 km per pipeline. A small percentage of onshore pipelines in the coastal subareas are directly the results of the OCS Program.

3.3.3.8.9. Coastal Barging

A general discussion of barging operations from offshore platforms to onshore terminals is found in Chapter 3.3.3.8.9. A discussion of the onshore barge terminals is found in Chapter 3.3.3.8.6.

The percentage of OCS oil barged (<1%) from offshore platforms to shore bases is only a small portion of the total amount of oil barged in coastal waters. There is a tremendous amount of barging that occurs in the coastal waters of the Gulf of Mexico, and no estimates exist of the volume that is attributable to the OCS industry. Secondary barging of OCS oil often occurs between terminals or from terminals to refineries. Oil that is piped to shore facilities and terminals is often subsequently transported by barge up rivers, through the Gulf Intracoastal Waterway, or along the coast.

3.3.3.9. State Oil and Gas Activities

3.3.3.9.1. Leasing and Production

Texas

The Lands and Minerals Division of the Texas General Land Office holds quarterly lease sales on the first Tuesday in January, April, July, and October of each year. Prior to July 1999, biannual sales were held.

The Texas coast is the largest along the Gulf of Mexico, spanning 400 mi and encompassing 12 counties. Texas also has the largest legal area of land extending Gulfward. Initially, all coastal states owned 3 mi of land into the Gulf of Mexico; however, with the enactment of the Submerged Lands Act and its interpretation by the Supreme Court in 1960, Texas land extends 3 marine leagues (10.4 mi). The State of Texas has authority over and owns the water, beds, and shores of the Gulf of Mexico equaling approximately 2.5 million acres.

The growth of the oil industry in the 20th century helped reform the State's land policy from an emphasis on income through the sale of land to an emphasis on income through resource management and development. The Texas General Land Office is directly responsible for the management of more than 22 million acres of land that remains in the public domain. According to the Relinquishment Act of 1919, a surface owner acts as leasing agent for the state on privately owned land where the State retains the mineral rights, and the State and surface owner share rentals, royalties, and bonuses.

The Texas Land Commissioner is authorized to lease designated public land for oil and gas production, and it now accounts for most of the income derived from public land. The State receives revenues from royalties, rentals, and bonuses. In addition to being leased for mineral production, land is leased for hunting, grazing, fishing, and commercial development. Land trades, experimental projects, and in-kind gas sales also provide revenue for the State. The Railroad Commission of Texas is the agency charged by the Texas Legislature with the regulation of the oil and gas industry in the State of Texas. The Commission's primary regulatory responsibilities are protecting the correlative rights of the mineral interest owners, preventing the waste of otherwise recoverable natural resources, and protecting the environment from pollution by oil and gas exploration and production activities.

In recent years, oil and gas production in the State of Texas has been declining. From 1978 to 1998 annual crude oil production fell from 1,040,966 million bbl to 457,499 million bbl. However, in that same time frame, the number of producing oil wells rose from 166,65 to 170,288. Natural gas production has shown a similar trend over the same time period. From 1978 to 1998, Texas natural gas production fell from 7,077.1 tcf to 5,772.1 tcf, and the number of producing gas wells rose from 33,157 to 58,436. Texas offshore oil and gas production for the year 2000 was 41,106 tcf of natural gas and 520,352 bbl of oil. Texas offshore oil and gas production for the year 2001 (as of May 2001) is 18,057 tcf of natural gas and 210,783 bbl of oil (Texas Railroad Commission, 2001).

Louisiana

The Louisiana Office of Mineral Resources holds regularly scheduled lease sales on the second Wednesday of every month.

The first oil production in commercial quantities occurred in 1901 and it marked the beginning of the industry in the State. The first over-water drilling in America occurred in 1910 in Caddo Lake near

Shreveport. The State began its offshore history in 1947. The territorial waters of Louisiana extend Gulfward for 3 mi and its shoreline extends nearly 350 mi.

Louisiana, through its aggressive mineral management programs, became the Nation's third leading producer of natural gas and the number four producer of crude oil in the country. When including the oil and gas production in the Gulf of Mexico, Louisiana becomes the second leading natural gas producer in the country and the third leading crude oil producer. There are 19 active refineries in the State of Louisiana, which accounts for 15 percent of the total refining capacity in the United States. There are thousands of miles of pipelines in the State carrying crude oil from the Gulf of Mexico to refineries in Louisiana and other states as well as carrying natural gas throughout the United States (Louisiana Mid-Continent Oil and Gas Association, 2001).

In 1999, Louisiana offshore production totaled 12.8 million bbl of crude oil from about 554 offshore oil wells and 147.5 tcf of natural gas from about 177 natural gas wells. In the same year, 44,645 persons were employed in the oil and gas production industry; 28,898 persons in the chemical industry; 11,046 persons in the oil refining industry; and 693 persons in the Oil Pipeline industry (Louisiana Dept. of Natural Resources, 2001). In fiscal year 1999-2000, $237,967,797 of royalties and $354,765,574 in severance tax were collected by the State on all oil and natural gas production taking place on State-owned lands and water bottoms (Louisiana Dept. of Natural Resources, 2001).

Mississippi

Mississippi's petroleum infrastructure includes four refineries including the Chevron refinery at Pascagoula and a moderately extensive network of crude oil, product, and liquefied petroleum gas pipelines. Mississippi ranks eleventh in the nation, including Federal offshore areas, in crude oil production, with 54,000 bbl per day. A major propane supply hub is located at Hattiesburg, Mississippi, where the Dixie Pipeline has a network of terminals and storage facilities. Natural gas as a primary heating fuel is used by 41 percent of homeowners, followed by electricity, which is used by about 31 percent of homeowners (USDOE, EIA, 2001c).

For onshore oil and gas development, the State of Mississippi passed legislation in 1994 allowing companies to enjoy substantial tax breaks based on the types of discovery involved and the methods they use. Those tax breaks range from a five-year exemption from the State's 6 percent severance tax for new discoveries to a 50 percent reduction in the tax for using 3-D technology to locate new oil and gas fields or for using enhanced recovery methods. As a result of the incentive program, 84 new oil pools have received the exemption, 108 inactive wells have been brought back into production, 13 development wells have been drilled in existing fields, 34 enhanced wells have received exemption, and 14 wells have received exemptions for using 3-D technology (Sheffield, 2000).

The State of Mississippi does not have an offshore oil and gas leasing program.

Alabama

Alabama has no established schedule of lease sales. The limited number of tracts in State waters is an inhibiting factor in scheduling regular lease sales. The last lease sale was held in 1997.

The territorial waters of Alabama extend Gulfward for 3 nmi and its shoreline extends nearly 52 mi. The first oil wells drilled for oil in the southeastern United States were drilled in Lawrence County in 1865, just six years after the first oil well in the United States. The first commercially marketed natural gas production in the southeastern United States occurred in the early 1900's near Huntsville. In 1979, gas was first discovered by MOEPSI in the mouth of Mobile Bay.

Alabama owns oil, gas, and mineral interests on small upland tracts, submerged river bottoms, estuaries, bays, and in the 3-mi area offshore. Most significant economically are the natural gas reserves lying within the 3-mi offshore area of Mobile and Baldwin Counties. The Alabama State Oil and Gas Board was created after the oil discovery in 1944 in Choctaw County and is responsible for regulating the exploration and development of these natural resources. The discovery of Alabama's giant Citronelle Field in Mobile County in 1955 focused national attention on the State's oil and gas potential. Major discoveries of natural gas in the 1980's led to the development of an array of natural gas reservoirs, and Alabama became a world leader in the development of coal-bed methane gas as an energy resource. The Norphlet Formation development, which started in November 1978, results in high production rates of gas from the Norphlet Formation. This gas is a hot, sour, high-pressure, corrosive mixture of methane, hydrogen sulfide, carbon dioxide, and free water.

Alabama has reaped tremendous financial benefits from the development of offshore mineral resources. Revenues include severance taxes, bonuses, royalties, and rentals. At present, Alabama is considered a major oil- and gas-producing state.

As of August 2001, a total of 69 test wells have been drilled in Alabama coastal waters. Forty of these wells were permitted to test the Norphlet formation below a depth of 20,000 ft. The two earliest wells were drilled to test undifferentiated rocks of Cretaceous age, and 27 wells have targeted shallow Miocene gas reservoirs generally at depths of less than 3,500 ft. Operators have experienced a high success rate in drilling wells in Alabama coastal waters. A total of 28 of the 40 wells drilled into the Norphlet Formation to date have tested gas, and 23 of the 27 Miocene wells drilled have tested gas. Sixteen gas fields have been established in the offshore region of the State with seven being productive from the Norphlet formation and nine being productive from sands of Miocene age (Alabama State Oil and Gas Board, 2001). Indigenous crude oil production totals 29,000 bbl per day, ranking Alabama 16th out of the 32 producing states and Federal offshore areas. The State's three refineries have a combined crude oil distillation capacity of 130,000 bbl per calendar day, while several crude oil, product, and liquefied petroleum gas pipelines pass through the State (USDOE, EIA, 2001c).

Production of gas from the State's coastal waters flows through 44 fixed structures and platforms and now exceeds 220 billion cubic feet annually. This accounts for approximately 50 percent of the total gas production in Alabama, which now ranks as one of the top 10 gas-producing states in the nation. Production capabilities for individual wells range from a few million to more than 110 million cubic feet per day (Alabama State Oil and Gas Board, 2001).

3.3.3.9.2. Pipeline Infrastructure for Transporting State Production

The pipeline network in the Gulf of Mexico states is extensive. Pipelines transport crude oil and natural gas from the wellhead to the processing plants and refineries. Pipelines transport natural gas from producing states such as Texas and Louisiana and to a lesser extent Mississippi and Alabama to utility companies, chemical companies, and other users throughout the nation. Pipelines are used to transport refined petroleum products such as gasoline and diesel from refineries in the Gulf of Mexico region to markets all over the country. Pipelines are also used to transport chemical products (Louisiana Mid-Continent Oil and Gas Association, 2001).

The natural gas pipeline network has grown substantially since 1990 nationwide. The increasing growth in natural gas demand over the past several years has led to an increase in the utilization of pipelines and has resulted in some pressure for expansion in several areas. In the Gulf of Mexico, after several consecutive years of extensive pipeline development, installation of additional offshore Gulf of Mexico pipeline capacity has slowed. In 1997 and 1998, 14 natural gas pipeline projects were completed and added a total of 6.4 billion cubic feet per day of new pipeline capacity, most of which represented large-capacity pipelines connecting onshore facilities with developing offshore sites, particularly in the deepwater areas of the Gulf. During 1999-2000, 8 significant projects were completed, adding 1.8 billion cubic feet per day to the area's pipeline capacity. The majority of these projects were built primarily to improve gathering operations and to link new and expanding producing platforms in the Gulf with recently completed offshore mainlines directed to onshore facilities (USDOE, EIA, 2001d).

Texas

The pipeline industry is a vital part of the oil and gas industry in Texas. At present, there are 218,000 mi under permit that transport natural gas, crude oil, and refined products. Of this figure, 142,000 mi are permitted to transport natural gas, 40,000 mi are permitted to transport crude oil, and about 36,000 mi are permitted refined products. The Railroad Commission of Texas' Pipeline Safety Section has safety jurisdiction for those pipelines that transport natural gas, crude oil, and refined products across Texas.

Louisiana

As in Texas, the pipeline industry is a vital part of the oil and gas industry in Louisiana. There are about 25,000 mi of pipe moving natural gas through interstate pipeline and about 7,600 mi of pipelines that carry natural gas through intrastate pipelines to users within the State's boundaries. Another 3,450 mi of pipe in Louisiana transport crude oil and crude oil products. There are thousands of miles of flow lines and gathering lines moving oil and gas from the wellhead to separating facilities, while other pipelines transport chemical products with no petroleum base. Louisiana is home to the world's only offshore superport, LOOP, which enables supertankers to unload crude oil away from shore so that it can be transported via pipeline to onshore terminals. The Henry Hub in Louisiana is a hub of pipelines and is the point where financial markets determine the value of natural gas (Louisiana Mid-Continent Oil and Gas Association, 2001).

Mississippi

The petroleum infrastructure in Mississippi includes a moderately extensive network of crude oil, product, and liquefied petroleum gas pipelines. A major propane supply hub is the Dixie Pipeline; it has a network of terminals and storage facilities. Major pipelines for crude oil are operated by EOTT Energy, Genesis, Hunt, Shell, Mid-Valley, Scurlock-Permian, and BP. Major pipelines for liquefied petroleum gas are operated by Dixie, Plantation, Enterprise BP Dixie, and Enterprise (USDOE, EIA, 2001c).

Alabama

Alabama's petroleum infrastructure includes a somewhat extensive network of crude oil, product, and liquefied petroleum gas pipelines. Major pipelines for crude oil are operated by Hess, Hunt, Genesis, Citronelle-Mobile, and Miller. Major pipelines for liquefied petroleum gas are operated by Dixie, and Enterprise (USDOE, EIA, 2001c).

3.3.3.10. Environmental Justice

On February 11, 1994, President Clinton issued Executive Order 12898, entitled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, which directs Federal agencies to assess whether their actions have disproportionate environmental effects on people of ethnic or racial minorities or with low incomes. Those environmental effects encompass human health, social, and economic consequences. The Federal agency in charge of the proposed action must provide opportunities for community input during the NEPA process (See Chapter 5 for a discussion of scoping, and community consultation and coordination.).

There are no environmental justice issues in the actual offshore Gulf of Mexico OCS planning areas; however, environmental justice concerns may be related to nearshore and onshore activities that result from a proposed action. These concerns are addressed in two categories—those related to routine operations and those related to non-routine events (accidents). Concerns related to routine operations center on increases in onshore activity (such as employment, migration, commuter traffic, and truck traffic) and on additions to or expansions of the infrastructure supporting this activity (such as fabrication yards, supply ports, and onshore disposal sites for offshore waste). Concerns related to nonroutine events focus on oil spills.

The OCS Program in the Gulf of Mexico is large and has been ongoing for more than 50 years. During this period, substantial leasing has occurred off Texas, Louisiana, Mississippi, and Alabama. An extensive support infrastructure system exists consisting of platform fabrication yards, shipyards, repair and maintenance yards, onshore service bases, heliports, marinas for crew and supply boats, pipeline coating companies, waste management facilities, gas processing plants, petrochemical plants, and gas and petroleum pipelines. This infrastructure system is both widespread and concentrated. Much infrastructure is located in coastal Louisiana, less in coastal Texas, and less still in Mississippi's Jackson County and Alabama's Mobile County. While many fabrication and supply facilities are concentrated around coastal ports, downstream processing is concentrated more in industrial corridors farther inland. Support system infrastructure is described in Chapters 3.3.3.4 and 3.3.3.10. The potential impacts to and from infrastructure is an ongoing concern for Gulf Coast States and communities. The MMS is currently conducting several studies to obtain and refine pertinent information. An ongoing study of infrastructure (Louis Berger Group, Inc., in preparation) is coding each facility and developing a database describing its functions and capacity. Ongoing cooperative agreements with Louisiana State University and the University of New Orleans are developing better descriptions and measures of the concentrated functions at specific coastal locations. Chapter 3.3.3.5 describes the even more widespread multitude of companies that provide goods and services to this system. One study (Applied Technology Research Corporation, 1994) counted 6,600 businesses that served oil and gas production companies. These vendors were distributed over 38 states, but they were concentrated in Texas, Mississippi, Alabama, and particularly Louisiana.

U.S. Census data aggregated at the county/parish level is too broad to reveal relationships between OCS leasing effects and geographic distributions of minority and low-income populations. Therefore, this environmental justice analysis considers the population distributions at the smaller, more detailed census tract level, which raises a data problem because tract-level household income data from the 2000 Census is not yet available. Because of the importance of geographic detail to the environmental justice analysis, MMS has opted to use 1997 projections of 1990 Census data for comparable and valid distributions for minority and low-income populations. While the 1997 projections are not expected to differ significantly from 2000 Census results, use of these projections raise additional issues. First, MMS purchased these data in 1997 and they do not include county/parishes recently added to the study area. Seven inland Texas counties were added to reflect the expanded Corpus Christi and Houston metropolitan areas; 12 inland Louisiana parishes were added to reflect the expanded Lafayette, Baton Rouge, and New Orleans metropolitan areas. Second, the U.S. Census 1997 nationwide definition of poverty was a household income of less than $16,276, while MMS data includes figures for income of greater than $15,000 and greater than $25,000. The MMS has chosen to use the lower figure since it is closer to the nationwide definition and since the cost of living is generally lower in the South than for the Nation as a whole.

Figure 3-15 maps census tracts that are 50 percent or more minority for the coastal areas of Texas, Louisiana, Mississippi, and Alabama. The MMS chose this percentage based on CEQ (1997) guidelines that defined a minority population of an affected that area exceeds 50 percent as an appropriate definition for environmental justice analysis. Most of these concentrations occur in large urban areas (such as Houston and Beaumont in Texas; Lafayette, Baton Rouge, and New Orleans in Louisiana; and Mobile in Alabama) or in smaller coastal urban areas (such as Corpus Christi and Galveston in Texas; Morgan City in Louisiana; and Gulfport, Biloxi, and Pascagoula in Mississippi). Large, rural, agricultural, predominantly minority census tracts are found in Texas, Louisiana, and Alabama. The Louisiana census tracts around Morgan City and along the Mississippi River below New Orleans are areas of mixed industry and agriculture. Both coastal areas are sparsely inhabited. These pockets of minority populations do not match the distribution of the offshore oil industry and its supporting infrastructure. Instead, they are the product of urbanization and of the historical role African Americans had in southern agriculture.

Figure 3-16 maps census tracts that have 50 percent or more of low-income households. The CEQ (1997) guidance for defining low-income areas is less explicit than it is for minority areas. The MMS selected the 50-percent level as comparable to the minority definition. In almost every case, these census tracts are neighborhoods in large or coastal urban areas (e.g., Galveston, Houston, Beaumont, Lafayette, Baton Rouge, New Orleans, Biloxi, and Mobile). Except in south Texas, all low-income census tracts are also minority census tracts. Again, like the concentrations of minority population, these pockets of poverty are a product of urbanization and southern agriculture.

As noted above, certain offshore fabrication and support functions are concentrated in coastal areas, particularly in Louisiana. Lafourche Parish, Louisiana, is described here because the analysis in Chapter 4.2.1.14 identifies it as a coastal area with a concentration of OCS-related infrastructure and with possible environmental justice concerns. Like its neighbors, Lafourche Parish is heavily involved in the offshore oil industry, particularly fabrication and support sectors. The founding and continued expansion of Port Fourchon, a port designed for deepwater OCS support, has added to the industry's presence (Keithly, 2001; Hughes, in preparation). Agriculture (primarily sugar cane and cattle) and commercial fishing make up smaller parts of the Lafourche Parish economy. In 2000, the parish's population was 89,974. Thibodaux, the parish seat and largest city, had a population of was 15,730; Larose, Raceland, and Cut Off had over 5,000 inhabitants; Galliano over 4,000; and Lockport and Golden Meadow over 2,000. The parish's population was 83 percent white (many of Cajun descent), 13 percent African American, 2 percent American Indian, and 1 percent Hispanic.

Much of Lafourche Parish is coastal wetlands. Habitable land—high ground—comprises narrow natural levees formed by existing and ancient bayous. Roads are built on top of these levees and communities are built along the roads and in the long, narrow bands described as "string settlements" (Davis and Place, 1983). This settlement pattern has tended to mix residential and business activities and to limit residential segregation by ethnicity and income. For example, the Houma, a State-recognized Indian tribe in the parish, resides interspersed among the dominant population group and are physically indistinguishable (Gibson, 1982; Fischer, 1970). Both the rich and the poor of Port Fourchon in Lafourche Parish have experienced the effects of port-related truck traffic; MMS scoping for this EIS and past EIS's has identified this as an issue of community-wide concern.

3.3.4. Recreational Resources

The northern Gulf of Mexico coastal zone has become increasingly developed over the past 20 years. In addition to homes, condominiums, and some industry, this coastline supports one of the major recreational regions of the United States, particularly for marine fishing and beach activities, both of which are viewed as public assets. There is a diversity of natural and developed landscapes and seascapes, including coastal beaches, barrier islands, estuarine bays and sounds, river deltas, and tidal marshes. Other recreational resources are publicly owned and administered, such as national and State seashores, parks, beaches, and wildlife lands, as well as designated preservation areas, such as historic and natural sites and landmarks, wilderness areas, wildlife sanctuaries, research reserves, and scenic rivers. Gulf Coast residents and tourists from throughout the nation, as well as from foreign countries, use these resources extensively and intensively for recreational activity. Commercial and private recreational facilities and establishments, such as resorts, marinas, amusement parks, and ornamental gardens, also serve as primary-interest areas. Locating, identifying, and observing coastal and marine birds, is a recreational activity of growing interest and importance all along the Gulf Coast.

The U.S. coastline along the Gulf of Mexico runs from Brownsville, Texas, and the southern tip of Padre Island, north, east, and south to the Dry Tortugas off Key West, Florida. It encompasses the confluence with the sea of the Mobile and Mississippi Rivers, which have two of the largest delta systems in the United States (Alabama State Docks Dept., 2001). More than 25 years ago, Congress set aside outstanding examples of Gulf coastal beach and barrier island ecosystems to be managed by the National Park Service for the preservation, enjoyment, and understanding of their inherent natural, cultural, and recreational values. State and county legislation added to this preservation program so that today there is a lengthy list of reserves, refuges, and public parks.

The shorefront of the northern Gulf of Mexico is diverse. It consists of national seashores such as Padre Island, traditional beachfront cities such as Galveston, State parks, marshland, casino-dotted beaches, the migratory bird habitats of Fort Morgan, and the sugar white sands of Gulf Shores, Alabama. Eco-tourism in national estuarine research reserves and beach recreation are interspersed with condominiums, hotels, planned communities, and private residences. Tourists and travelers are also attracted to the sites, sounds, shopping, and dining associated with developed marine areas.

The value of recreation and tourism in the Gulf of Mexico coastal zone from Texas through Florida has been estimated in the tens of billions of dollars annually (USDOI, MMS, 2001g; pages III-101 and III-102). A significant portion of these expenditures is made in coastal counties, where major shoreline beaches are primary recreational attractions. For example, well over 1 million people visited the beaches of Galveston Island and the Padre Island National Seashore in 1996, demonstrating the popularity of destination beach parks throughout the WPA as recreational resources.

Over 1 million people visit the mainland unit and barrier island beaches of the Gulf Island National Seashore in Mississippi and Florida annually, demonstrating the popularity of destination beach parks throughout the Gulf Coast region east of the Mississippi River. Trash and debris from OCS operations can wash ashore on Gulf of Mexico recreational beaches. Recreational beaches west of the Mississippi River are most likely to be impacted by waterborne trash from the OCS. Litter on recreational beaches from OCS operations could adversely affect the ambience of the beach environment, detract from the enjoyment of beach activities, and increase administrative costs on maintained beaches. Some trash items, such as glass, pieces of steel, and drums with chemical residues, can also be a health threat to users of recreational beaches. Current industry waste management practices; training and awareness programs focused on the beach litter problem; and the OCS industry's continuing efforts to minimize, track, and control offshore wastes are expected to minimize the potential for accidental loss of solid wastes from OCS oil and gas operations.

In this section, the coastline has been divided into segments according to topography, discrete human and other biological populations, barrier island formations, and special preservation areas. This gives the reader the chance to put in geographical context the textual descriptions.

Texas — Coastal Bend

From west to east, the counties of the Texas Coastal Bend area are Cameron, Wallacy, Kenedy, Kleberg, Nueces, and Aransas Counties. The coastal features include Padre Island, the Padre Island National Seashore, and Laguna Madre. The region boasts Corpus Christi Bay of the National Estuary Program and the western end of the Gulf Islands National Seashore, according to the Center for Marine Conservation web site as of May 10, 2001. There also are a State-designated coastal preserve at South Bay, a State park at Boca Chica, and the Port Isabel Lighthouse State Historical Park, all in Cameron County. Further up the coast in Nueces County, Mustang Island State Park is just south of Port Aransas, and Goose Island State Park is in Aransas County.

Texas — Matagorda

This segment includes Calhoun and Matagorda Counties. Matagorda Island is a barrier island protected under the Texas General Land Office's delineation of the Matagorda Island State Park and Wildlife Management Area.

Texas — Galveston

There are three counties in this portion of the shoreline: Brazoria; Galveston; and Chambers. Galveston Bay is part of the National Estuary Program. On the western perimeter of the Bay are the San Jacinto Battleground State Historical Park and the Battleship *Texas*. Galveston Island State Park is on the western end of Galveston Island.

Texas — Sea Rim

This stretch of the Texas coast includes Jefferson County and Sea Rim State Park. Nearby is the Sabine Pass Battleground State Historical Park.

Louisiana — Beaches

The three parishes of Cameron, Lafourche, and Jefferson comprise this segment. Spanning part of this coastline is the Barataria-Terrebonne National Estuary, the Atchafalaya National Wildlife Refuge, and the Jean Lafitte National Historic Park and Reserve.

Mississippi and Alabama — Gulf Islands

Gulf Islands National Seashore in this part of the Gulf stretches some 40 mi from Hancock, Harrison, and Jackson Counties in Mississippi to neighboring Mobile County and Dauphin Island in Alabama and over into the Florida Panhandle. This part of the National Seashore accommodates more than 1 million recreational visits a year. In addition to beaches, the Seashore harbors historic forts, shipwrecks, wetlands, lagoons and estuaries, seagrass, fish and wildlife, and archeological sites. In 1978, Congress designated approximately 1,800 ac on Horn and Petit Bois Islands, part of Gulf Islands National Seashore in Mississippi, as components of the National Wilderness System. And there is a national estuarine research reserve at Grand Bay (Weeks Bay Reserve Foundation, 1999).

Alabama — Gulf Shores

The southernmost part of Baldwin County is also known as Pleasure Island. It was a peninsula until the U.S. Army Corps of Engineers built the intracoastal waterway and cut the land ties to the mainland. Mobile Bay is part of the national estuary program, and Weeks Bay, at the southeastern end of the bay, is also part of the national estuarine research reserve system.

Florida Panhandle — West

This segment encompasses the three counties of Escambia, Santa Rosa, and Okaloosa. The area includes the eastern portion of Gulf Islands National Seashore, which is known as the Emerald Coast. Grayson State Park in Escambia County is near the Alabama/Florida state line.

Florida Panhandle — East

The four counties of Walton, Bay, Gulf, and Franklin are adjacent to Florida's Big Bend. St. George's Island is the easternmost of the system of barrier islands in the Gulf of Mexico. The Apalachicola National Estuarine Research Reserve has been established in this area to preserve the delta, river, and bay.

Florida — Dixie Stretch

Also known as the Big Bend stretch of Wakulla, Jefferson, Taylor, Dixie, Levy, Citrus, and Hernando Counties, this area is characterized by few recreational or tourist sites. This stretch of the coast includes the St. Vincent, St. Marks, Lower Suwannee, Cedar Keys, Crystal River, and Chassahowitzka National Wildlife Refuges, and the Homosassa Springs State Wildlife Park.

Florida — Southwest

This is the largest segment, running from Pasco, Hillsborough, Manatee, Sarasota and Charlotte Counties south to Lee County. There are three bays that have become part of the national estuarine program: Tampa Bay; Sarasota Bay; and Charlotte Harbor.